Quizix

6000 Series Pump System User's Manual

Chandler Engineering Company L.L.C.
P.O. Box 470710, Tulsa, Oklahoma 74147-0710 U.S.A.
Phone: (918) 250-7200 Fax: (918) 459-0165
E-mail: chandler.mail@ametek.com Website: http://www.chandlereng.com

December 2012
Version C

CHANDLER ENGINEERING®

AMETEK®

1 General Overview

This manual, the 6000 Series Pump System User's Manual, provides operating and maintenance instructions for the "hardware" of all 6000 Series pump systems. A separate manual, the PumpWorks User's Manual, discusses the software which operates all Quizix pump systems.

This chapter provides an introduction to the 6000 Series Pump System and includes an overview of its components.

1.1 Introduction

Of the three lines of pump systems manufactured by Chandler Engineering, the 6000 Series is the largest. It is designed for users who require greater flow rates or larger fluid volumes than the 5000 Series provides. Three different pump cylinder models are available in the 6000 Series with different maximum flow rate and pressure specifications (see Figure 1-1).

The 6000 Series Pump Cylinders				
Model	Maximum Pressure (psi)	Maximum Flow Rate (ml/min)	Piston Stroke Volume (ml)	Piston Diameter (inch)
Q6105	5,000	400	550	2.00
Q6110	10,000	200	275	1.41
Q6115	15,000	100	135	1.00
Q6120	20,000	100	135	1.00

Figure 1-1 6000 Series Pump Cylinders

Like the QX Series and 5000 Series, the 6000 Series Pump System provides continuous, pulse–free fluid flow for use in core analysis and related research. Key features of the system include the following:

- The 6000 Series Pump System is designed for pumping fluids at high pressure and provides precise pressure control.
- The system works well with water, oil, or brine. Fluid-wetted parts are available in Hastelloy (C-276) for users pumping highly corrosive fluids.
- Sophisticated electronics provide highly accurate fluid flow rates and volume measurement.
- The system is operated using Quizix PumpWorks© Software which runs on a PC-compatible computer (486, or Pentium® based, 66 mhz minimum), using Windows 95, Windows 98, Windows NT, Windows 2000, or Windows XP operating systems. The software provides the user with complete control over all operating parameters.

- The pump system can be operated in many different operating modes, including Constant Rate, Constant Pressure, and Constant Delta Pressure. The system can operate in both directions: either delivering or receiving fluid.

- Quizix PumpWorks software permits system–level integration of the user's entire experiment. The user can add additional valves or pressure transducers and export data using a host link or Dynamic Data Exchange (DDE).

- A high temperature (160° C) option is available, which allows the user to heat the entire pump cylinder.

- The pump system is expandable and is designed to allow the user to add additional pump cylinders, as their needs change.

1.2 Primary Components

The 6000 Series Pump System is designed as a modular component system. Systems can contain anywhere from one to eight pump cylinders. Two pump cylinders are necessary for continuous flow of a single fluid. The primary components of 2-cylinder and 4-cylinder 6000 Series Pump Systems are as follows:

Q6200 (2–Cylinder) Pump System
2 Q6 Pump Cylinders (choice of models)
2 constant volume valves
2 pressure transducers
1 CN-6000 Pump Controller
1 Serial Expander/Isolator
Plumbing and cables
PumpWorks software
1 PC-compatible computer (486 or Pentium-based, 66 mhz minimum)

Figure 1-2

Q6400 (4–Cylinder) Pump System
4 Q6 Pump Cylinders (choice of models)
4 constant volume valves
4 pressure transducers
2 CN-6000 Pump Controllers
1 Serial Expander/Isolator
Plumbing and cables
PumpWorks software
1 PC-compatible computer (486 or Pentium-based, 66 mhz minimum)

Figure 1-3

The 6000 Series ambient temperature pump cylinder is shown in Figure 1-4. The 6000 Series high temperature pump cylinder is shown in Figure 1-5.

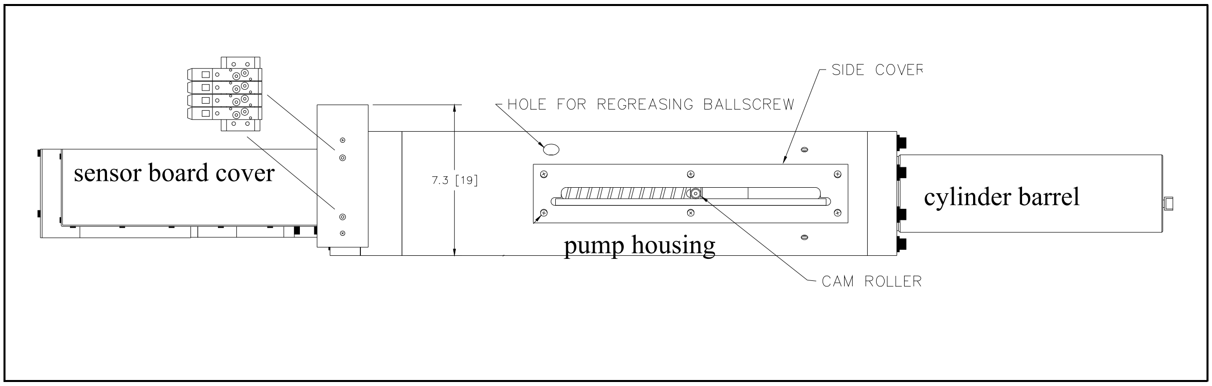


Figure 1-4 Pump Cylinder Side View, Ambient Temperature

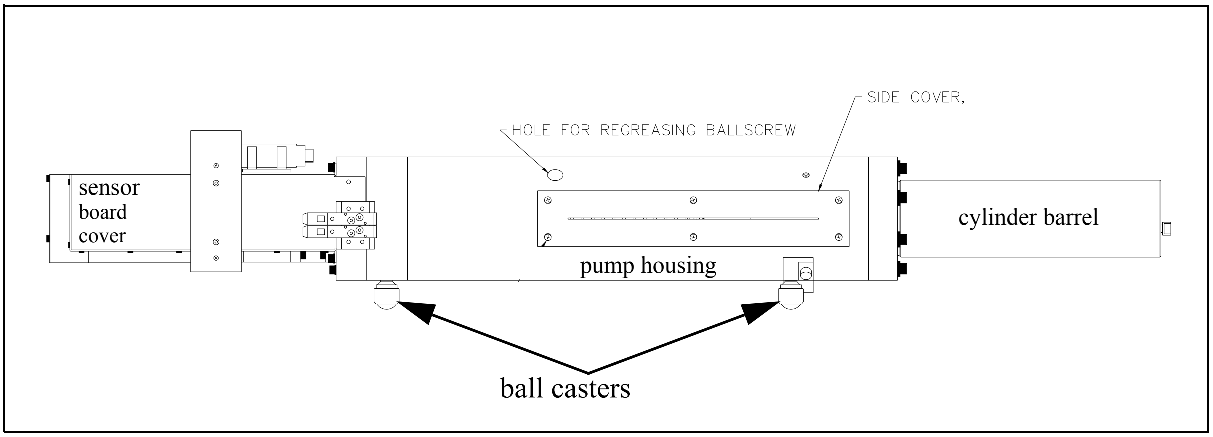


Figure 1-5 Pump Cylinder Side View, High Temperature

NOTE ON NOMENCLATURE: The terms "pump cylinder" and "cylinder" are used interchangeably throughout this manual, and refer to the entire mechanical component used to pump fluid, as shown in Figure 1-4 and Figure 1-5. Pump cylinder part numbers begin with a "Q". For example, Q6210.

The term "pump system" refers to one or more pump cylinders **together with** one or more pump controllers, valves, transducers, plumbing and PumpWorks software. The part number for an entire pump system begins with "Q". For example, a 6200 10K pump system includes two Q6 10K cylinders. The number of pump cylinders in a system is given by the number following the "6".

In a pump system with two or more pump cylinders, the cylinders in a pair are typically labeled "A" and "B" because most users operate their pump cylinders in pairs for continuous fluid flow. For example, a Q6400 would include four pump cylinders labeled 1A, 1B, 2A, and 2B.

A 6000 Series Pump System includes the following components:

1.2.1 Q6000 Pump Cylinder and Motor Driver

The pump cylinder is the basic building block of the system. It is the component that performs the actual pumping. A system can include any number of pump cylinders--from one to eight--depending on the type of experiments the user plans to conduct.

A system can operate using pump cylinders individually, in pairs, or as coordinated pairs. Generally, a pair of pump cylinders is used to provide continuous flow of one fluid. Working as a pair, one pump cylinder delivers the fluid while the other pump cylinder fills with fluid, pre-pressurizes, and waits for its turn to deliver fluid.

The motor driver is included as part of the Q6000 pump cylinder. The motor driver is mounted to the rear of the pump cylinder next to the motor.

The sensor and driver cables of the Q6000 are connected to a CN-6000 Pump Controller. The CN-6000 Pump Controller can be used to control two Q6000 pump cylinders and can be conveniently mounted on the side of the pump housing.

1.2.2 CN–6000 Pump Controller

The pump controller is the "brains" of the entire system. It coordinates the operation of all the pump components and operates the system according to settings made by the user via PumpWorks. The pump controller is a two–channel unit, which operates two pump cylinders. Additional pump controllers are used to control up to eight pump cylinders which can be operated from PumpWorks.

1.2.3 Serial Expander/Isolator

The Serial Expander/Isolator is a device which expands one serial port of a computer into four serial ports. It allows the user to connect up to four pump controllers to a single computer serial port. It also isolates the electrical signals (generated by the computer) from the data signals that go to the user's pumps.

1.2.4 PumpWorks Software and Computer

The pump system includes PumpWorks software©, which runs on a PC-compatible computer (486 or Pentium® based, 66 mhz minimum), using Windows 95, Windows 98, Windows NT, Windows 2000, or Windows XP operating systems. The user may supply the computer or purchase a computer system from Chandler Engineering with the pump system.

PumpWorks is menu–driven and easy to use. The software allows the user to set operating parameters, such as fluid flow rate or pressure. PumpWorks provides the user with full system status information at all times. Data logging capabilities are available, allowing the user to automate data collection. Many other useful features are included and described in the PumpWorks User's Manual.

1.2.5 Valves, Transducers and Plumbing

For each pump cylinder, the system includes one air–actuated three–way valve, two pilot solenoids, and one pressure transducer. All necessary plumbing and cables are also included.

1.2.6 Support Stand

The 6000 Series ambient temperature pump cylinders do not have a support stand but are designed to be attached together in vertical stacks and can be put on a bench or cart. They can be supplied with ball casters.

The 6000 Series high temperature pump cylinders do not have a support stand but is designed to stand alone for oven installation and comes with a heat shield and ball casters.

This page intentionally left blank.

2 System Setup

Chapter 2 provides the information necessary to set up a 6000 Series Pump System for the first time, or change a system's setup. The following sections are included:

- Unpacking the System, Section 2.1
- Inspecting Your Pump, Section 2.2
- Stacking the Pump Cylinders, Section 2.3
- Color Coding, Section 2.4
- Connecting the System Components, Section 2.5
- Connecting to a Power Source, Section 2.6
- Turning on Your Pump Controller, Section 2.7
- Installing PumpWorks on Your Computer, Section 2.8
- Starting PumpWorks and Installing A Pump, Section 2.9
- Installing the Piston, Section 2.10
- Installing the Cylinder Barrel, Section 2.11
- Installing the Valves and Transducers, Section 2.12
- Connecting the Air Supply, Section 2.13
- Connecting Your Fluid Plumbing, Section 2.14
- Setting Up a High Temperature System: Oven Installation, Section 2.15

2.1 Unpacking the System

To unpack the 6000 Series Pump System, first prepare a location for the pump cylinders. Ensure that the location can support the weight of the pump cylinders and associated equipment. When assembled, each pump cylinder weighs about 80 kg (175 lbs). A cart can be used if it is desired to be able to move the pump cylinders.

To unpack the system, do the following:

Figure 2-1

1. Open the wooden crates by removing the screws on the top of the crate. Then remove the crate lids.
2. Each crate contains an inner wooden box. Remove the lids on these box.
3. 20K pump systems may have some components shipped in separate cardboard boxes. Open these boxes and lay the components out..

IMPORTANT
For 5K and 10K pump systems, the valve assembly is placed inside the wooden crate near the pump motor or beneath the motor driver. Move the valve assembly to a safe location before the pump cylinder is removed. For 20K pump systems, the valves will be shipped in a separate box.

4. Check that no cables are caught on the crate and that the pump cylinder moves freely when lifted. Each pump cylinder has two attached lifting rings. Use a crane, or block and tackle, to lift the pump cylinders from the crate to a cart. Now transfer the pump cylinders to your prepared location.

CAUTION
To keep dust out of the pump cylinders, red plastic plugs are inserted in the open holes of the pump cylinder. These plugs are not rated for high temperature use. The continuous use rating of these plugs is 66° C (150° F). Remove all red plastic plugs before operating above this temperature. For high temperature pump systems, there are three medium plugs, and one large plug located on each pump cylinder.

2.2 Inspecting Your Pump

Before doing anything else, **STOP** and inspect your new pump system components.

Do not install your new pump if you suspect it has been damaged in transit.

To make sure no damage has occurred to the pump system during shipping, inspect the components. No scratches or dents should be visible. The tubing should not be crimped or have any irregular bends. It is your responsibility to notify the shipping company immediately of any damage.

- Check the crates and boxes for damage. Then check the corresponding area on the system components. A component may have been damaged, even if the box has only slight damage. If the pump is damaged in any way, notify the shipping company.

After informing the shipping company of any damage, also inform Chandler Engineering. You can reach us at the following numbers:

Phone:	918-250-7200	8:00 a.m. to 5:00 p.m. CST
Fax:	918-459-0165	24 hours a day, 7 days a week
E-mail:	chandler.sales@ametek.com	24 hours a day, 7 days a week

2.3 Stacking the Pump Cylinders

The 6000 Series Pump Cylinders can be stacked on top of each other. For users with two or more ambient temperature cylinders, it is preferable to stack the pump cylinders in pairs. When installing high temperature pump cylinders through an oven wall, it is usually more convenient to construct shelves that hold individual pump cylinders rather than stacks.

If the cylinders are stacked in pairs, be sure to place the pump cylinder designated "A" (which has the CN-6000 Pump Controller mounted on its side) on the BOTTOM. The pump cylinder designated "B" should be placed on TOP. The "B" pump cylinder typically has the valve manifold and pilot solenoids attached to it. Thus, in a typical stacked pair, the pump controller

will be on the A" cylinder on the bottom and the valve manifold will be directly above it on the "B" cylinder.

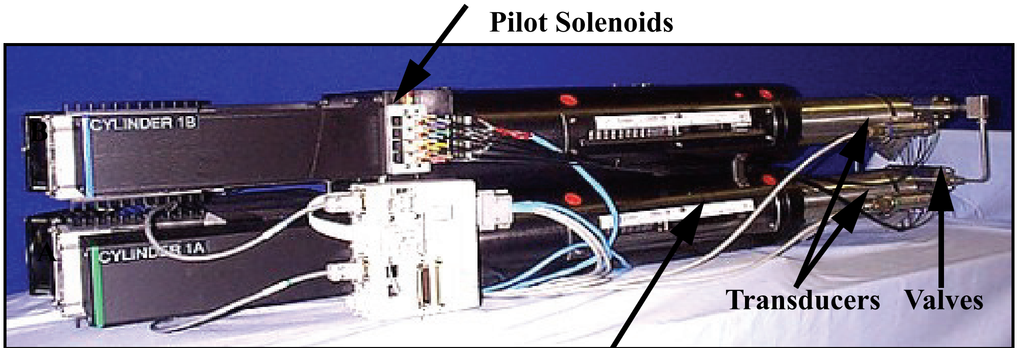


Figure 2-2

The pump cylinders are connected together with two angled mounting brackets and two straight mounting brackets and fastened with metric socket screws. The brackets are attached loosely to the pump cylinders during shipping. Contact Chandler Engineering if you need more brackets.

There are two angled mounting brackets which will be conneced to pump cylinder A when shipped. One is located on the front side and one is located on the back side. Both are located between pump between cylinders A and B near the pump housing, as shown in Figure 2-2 above. A close-up of the angled mounting brackets is shown in Figure 2-3.

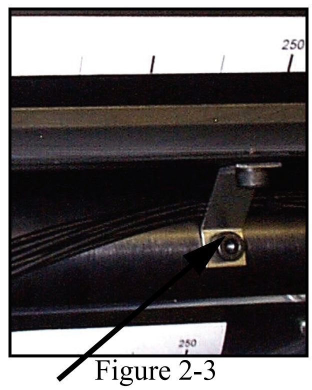


Figure 2-3

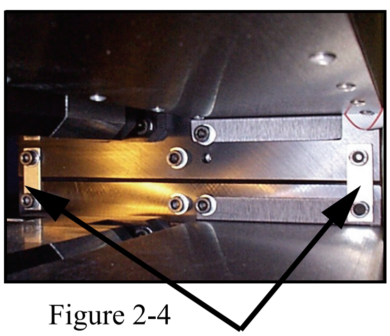


Figure 2-4

The two straight mounting brackets, shown in Figure 2-4, are located behind the pump controller between cylinders A and B. Chandler Engineering suggests that you use a long handled hex driver tool to tighten the straight brackets, as shown in the picture below.

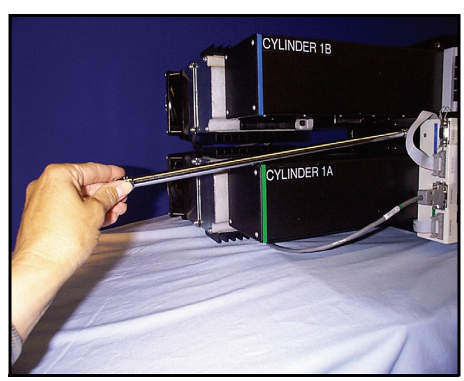


Figure 2-5

Users with three or four Q6000 pump cylinders can stack the pump cylinders in a single stack if there is very little space available. It is important to stack the cylinders in the following numerical order:

Pump Cylinder 2B (on the top)

Pump Cylinder 2A

Pump Cylinder 1B

Pump Cylinder 1A (on the bottom)

NOTE: This is a different order than that of the 5000 Series stand for a 4-cylinder system. Users who own both 5000 series and 6000 series pumps should be careful not to confuse the pump cylinder numbers.

IMPORTANT
For safety reasons, do not place more than four pump cylinders in a vertical stack. Secure tall stacks from tipping over. If possible, it is preferable to stack only two pump cylinders together.

2.4 Color Coding

The Q6000 Pump Series is color coded for the user's convenience. A color code has been assigned to each pump cylinder as shown in Figure 2-6.

PUMP CYLINDER	COLOR
Pump Cylinder A	Green
Pump Cylinder B	Blue

Figure 2-6 Pump Color Code

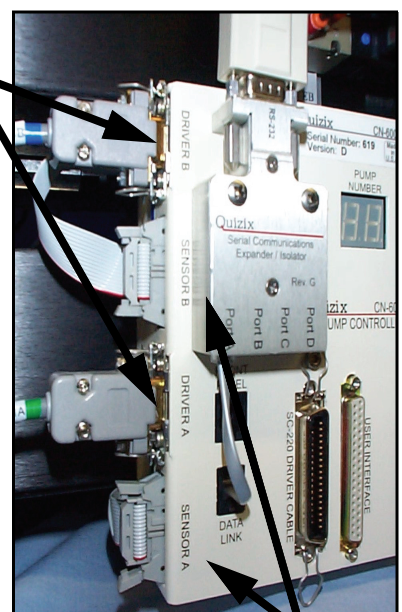


Figure 2-6

The above color coding is used not only for the pump cylinders, but also the transducer, transducer cables, driver cables and sensor cables as well.

2.5 Connecting the System Components

2.5.1 Driver and Sensor Cables

1. For the first cylinder, the cables labeled "Driver A" and "Sensor A" will typically already be connected to the CN-6000 Pump Controller, which is mounted on the side of Pump Cylinder A. For the second cylinder, connect the cable labeled "Driver B" to the receptacle on the

CN-6000 Pump Controller labeled "Driver B". Connect the cable labeled "Sensor B" to the receptacle labeled "Sensor B".

2. If you have three pump cylinders, the cables labeled "Driver A" and "Sensor A" will typically already be connected to the corresponding receptacles on the SECOND CN-6000 Pump Controller (which will be mounted on the side of the third cylinder). Typically, controller #1 is the one with a serial expander/isolator mounted directly on the CN-6000 Pump Controller and controller #2 is the one without a serial expander/isolator.

3. If you have four pump cylinders, connect the "Driver B" and "Sensor B" cables into the appropriate receptacles on the SECOND controller. If you have five or six cylinders, repeat these steps by connecting the driver and sensor cables correctly to the third controller.

2.5.2 Data and RS-232 Cables

1. The Data Cable from the CN-6000 Pump Controller will already be connected to the Serial Expander/Isolator mounted directly on it. If you have a second Pump Controller, connect the Data Cable from it to the connector on the Serial Expander/Isolator labeled "Port B".

2. Connect one end of the RS-232 Cable (9 pin D Connector) to the Serial Expander/Isolator. Connect the other end to Communications Port 1 on the back of the computer that will be used to run PumpWorks. (Communications Port 1 may be labeled Serial A or Serial 1 on your computer.)

3. If Communications Port 1 is already in use, you may use any other available serial port and then reconfigure the Communications accordingly. Please refer to the PumpWorks User's Manual for more information.

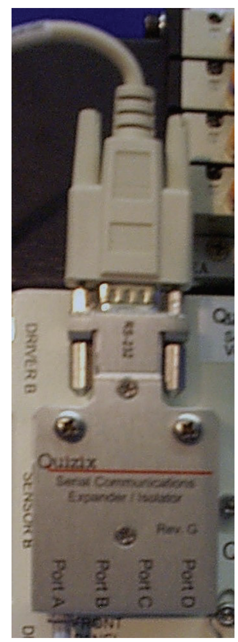


Figure 2-7

Figure 2-8

2.5.3Transducer and Valve Cable

1. There is one cable which connects the Pump controller to both the pilot solenoids for the valves and to the pressure transducers. Connect this cable to the receptacle on the pump controller labeled "Pressure Transducer & Valve Cable", located on the top right side of the pump controller. Plug the two-pin connectors into the pilot solenoids on the valve manifold, which is typically mounted on the second cylinder. The pilot solenoids and the two-pin connectors have been numbered. Plug each numbered

cable branch into the pilot solenoid with the same number (cable branch into pilot solenoid 1, etc.).

2. Next, connect the strand labeled "Transducer A" to the transducer which will later be mounted onto the first pump cylinder. Connect the strand labeled "Transducer B" to the transducer which will be mounted onto the second pump cylinder. At this point in the system setup, the transducers and valves will usually not be mounted onto the pump cylinders yet, but it is still essential to connect this cable so that the pumps can be run during the piston installation process.

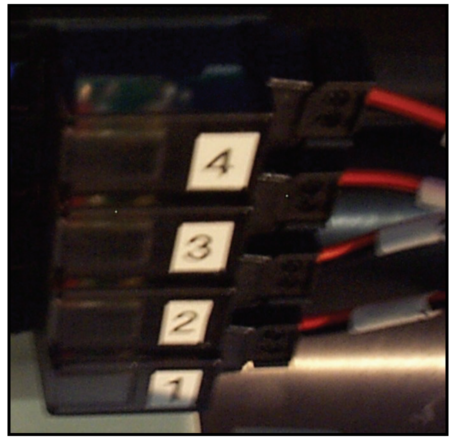


Figure 2-9

3. If you have more than two pump cylinders, repeat these steps for the Transducer and Valve Cable for the second Pump Controller. Because the Transducer and Valve Cable is designed for two pump cylinders, if your system has an odd number of pump cylinders, there will be cable strands which are not used.

2.6 Connecting to a Power Source

1. Plug the power cable from the motor driver for each pump cylinder in your system to a **120 volt AC source. For countries that use 220 or 240 volts AC, a 120 volt step-down power transformer is provided.**

Figure 2-10

WARNING
THE MOTOR DRIVERS FOR THE 6000 SERIES PUMPS ARE COMPATIBLE ONLY WITH 120 VOLTS AC. DO NOT USE THEM WITH 220 OR 240 VOLTS AC POWER.

If the country to which the system was shipped does not have 120 volts AC as standard power, a transformer is provided for the motor driver. In this case, connect the motor driver power cord to the transformer, then connect the transformer to the power outlet.

2. Plug the CN-6000 Pump Controller to an AC power source. The CN-6000 Pump Controller operates on a universal AC supply (voltage range of 85 to 264 volts AC, 47-63 Hz) and is compatible with 110, 220 or 240 volt AC power. It consumers less than 5 watts. The power cord supplied will agree with the voltage in the user's country.

Figure 2-11

3. Plug the power cord for your computer into an AC power source. If the computer was ordered from Chandler Engineering with the pump system, it is set for the voltage in use in your country. See the operating manual that came with your computer for further information about its power specifications.

2.7 Turning on Your Pump Controller

The CN-6000 Pump Controller has a two-digit display, which is labeled "Pump Number." Using letters, numbers, or a combination of the two, the two-digit display can convey overpressure or underpressure errors, communication errors, driver errors, or the absence of a cable. If no errors are present, the two-digit display will show the pump number (1,2,3, and so on). When turning on the pump controller, the user needs to watch the two-digit display.

READ THE REST OF THIS SECTION ON HARDWARE AND SOFTWARE DIAGNOSTICS BEFORE ACTUALLY TURNING ON YOUR PUMP CONTROLLER.

To turn on your pump controller, push the on/off button in. The on/off button is red and is located on the side of the pump controller.

Watch the two digit display when you turn on your pump controller.

- The first thing the user will see is all segments of the display will light at once, briefly.
- Next the display will flash the boot version number.

The following two sections will explain the Pump Controller Hardware Diagnostics (Pump Controller Hardware Diagnostics, Section 2.7.1) and Pump Controller Software Diagnostics (Figure 2-13 Pump Controller Software Diagnostics, Section).

2.7.1 Pump Controller Hardware Diagnostics

The basic pump controller diagnostics are performed next. Refer to Figures 2-13 and 2-14. The right hand digit will light, the left hand digit will not. One segment of the right hand digit will light at a time, starting with the top segment as shown in Figure 2-2. One segment lights, then a second segment lights, then a third, and so on. Each segment that lights is a confirmation that a specific aspect of the pump controller is operating correctly.

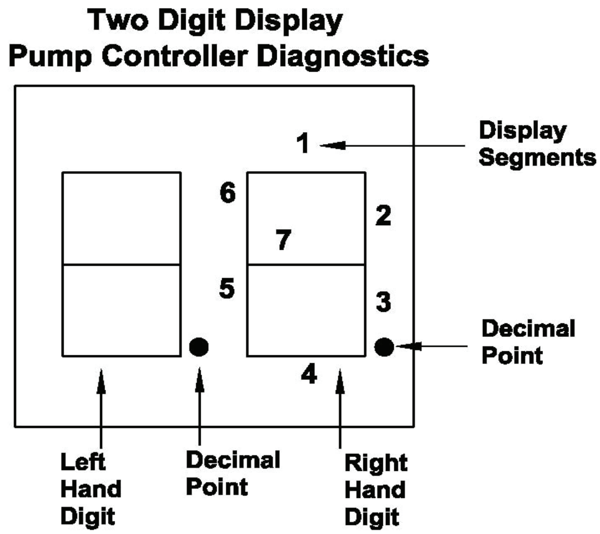


Figure 2-12 Two Digit Display

```
1st    2nd    3rd    4th    5th    6th    7th
___    ___    ___    ___    ___    ___    ___
          I      I      I      I   l   I  I__ I
                 I   ___I   I___I  I___I  I___I
```

Figure 2-13 Pump Controller Software Diagnostics

The controller diagnostics are performed next. This time the left hand digit will light and the right hand digit will not. The left hand digit will display number 1, then 2, then 3, then 4, then 5, then 6, then 7, then 8. As each number lights, it is a confirmation that a pump controller software function is operating correctly. Each number will flash quickly.

In the final step, “do” will flash alternately with “O”. The “do” stands for digital overpressure. As a safety precaution, pumps are shipped with a safety pressure set at -50 PSI. You will be instructed how to reset the safety pressure in Section 2.10. The “O” means the pump has not yet been assigned a pump number by PumpWorks. This will be done in Starting PumpWorks and Installing A Pump, Section 2.9.

If your pump controller follows the above described steps, it has been successfully turned on and passed the internal start-up diagnostic checks. If, however, your pump stops at one of the steps, go to Chapter , **Section 12.3**, for help in diagnosing the problem.

2.7.2 Uninterruptable Power Supplies (UPS)

Electronic equipment, including the Series 6000 Pump System and your computer, can be affected by brief power interruptions and by power line surges or spikes. An Uninterruptable Power Supply (UPS) can provide back–up power to your equipment during such occurrences. This will prevent your pump from stopping when power interruptions or fluctuations occur.

To prevent disruption to an experiment, it is strongly recommended that users who are interested in obtaining continuous fluid flow over extended periods of time use a UPS with their pump system. For more information about choosing a UPS, see Section 10.2, “"Using Uninterruptable Power Supplies"”.

2.8 Installing PumpWorks on Your Computer

If you purchased a computer from Chandler Engineering with your 6000 Series Pump System, PumpWorks has already been installed for you. Otherwise, make sure the computer you will be using meets the following hardware requirements:

- PC-compatible computer (486 or Pentium based minimum),
- 3-1/2” 1.4 MB disk drive or CD Rom
- 2 MB available hard disk space, and

1. Insert PumpWorks disk into your computer.

2. Using either Windows Explorer or File Manager, double-click on or run “setup.exe”. The PumpWorks wizard application guides you through the software installation until PumpWorks is completely installed on your computer.

2.9 Starting PumpWorks and Installing A Pump

There are two methods for installing your Q6000 Pump Cylinders onto PumpWorks. One is an automatic search for new pumps when PumpWorks is started. The second method is to search for pumps while PumpWorks is operating. We will describe both methods below. We recommend the first method, Section 2.9.1, "Automatic Search For New Pumps When Starting PumpWorks".

2.9.1 Automatic Search For New Pumps When Starting PumpWorks

1. Be sure all pump cylinders to be installed are connected and their motor drivers are turned on before starting PumpWorks. Go to Start > Programs > and double left click on PumpWorks 95-NT. PumpWorks will automatically search for new pumps. When PumpWorks finds a new pump, the following message will display:

   CN-6000 found on Com 1: Expander Port A (or B, C or D)
   Do you wish to install?

2. Click on “Install”.

3. PumpWorks will ask you to “Enter User Name for New Pump”. The default pump name is Pump 1, Pump 2 and so on. If you don’t want to change the name now, you may do so at any time from PumpWorks main window.

4. Click on “Install”.

5. When PumpWorks starts, the “Main Pump Data & Controls” window will be showing. You will know that your pump has been installed because:

   - The pump name will appear in black letters (either Pump 1, Pump 2 and so on or the user-given pump name). If no pump is present, the default pump name appears in gray letters.
   - The pump data fields will contain numbers instead of question marks.

2.9.2 User Search For New Pump Controller

This method is a good way to install a new pump onto an existing PumpWorks system, where PumpWorks is already running and the user does not wish to exit PumpWorks in order to perform an automatic search for new pumps. It is assumed, then, that PumpWorks is already operating.

1. Be sure the data link cable is connected from the new pump controller to a serial expander/isolator port.
2. Turn on power to the new pump controller and the pump cylinder’s motor driver.
3. Click on: “Communications > Search For Pumps”. PumpWorks will search for your new pump and give you a message that says:

   CN-6000 found on Com 1: Expander Port A (or B, C or D)
   Do you wish to install?

4. Click on “Install”.

5. PumpWorks will ask you to “Enter User Name for New Pump”. The default pump name is the lowest pump number available, as in Pump 1, Pump 2 and so on. If you don’t want to change the name now, you may do so at any time from PumpWorks main window.

6. Click on “Install”.

7. PumpWorks brings up the “Main Pump Data & Controls” window. You will know your pump has been installed because of the following:

   - The pump name will appear in black letters (either Pump 1, Pump 2 and so on or the user-given pump name). If no pump is present, the default pump name appears in gray letters.

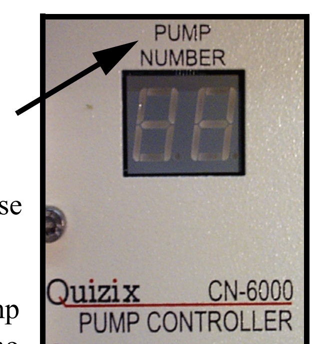


Figure 2-14

- The pump data fields will contain numbers instead of question marks.

2.9.3 Two Digit Display When Pump Is Installed Onto PumpWorks

The two digit display on the pump controller is a way for the pump to communicate information to the pump user. When you install a brand new pump for the first time, the error message “do” will continue to flash alternately with the pump number (1, 2, 3, 4, 5, 6, 7 or 8) on the right hand digit of the two digit display. The “do” stands for digital overpressure. As a safety precaution, the safety pressure is reset to -50 PSI when the pump is turned on. You will be instructed how to reset the safety pressure in Section 2.11.

The pump number is assigned by PumpWorks based on the first available screen position, starting from left to right, on PumpWorks Main Window.

NOTE: When PumpWorks and the CN-6000 Pump Controller are communicating with each other, decimal points on the two digit display will flash. A decimal point will flash on the right side of the right digit, which means the CN-6000 is sending communications to PumpWorks. A decimal point will flash on the right side of the left digit, which means that PumpWorks is sending communications to the CN-6000. The right digit decimal point will flash brighter than the left digit decimal point because the CN-6000 has more data to send to PumpWorks than the amount of data PumpWorks has to send to the CN-6000.

2.10 Installing the Piston

6000 Series pump cylinders are shipped with their pistons packed separately to avoid breakage. 6000 Series pistons are made of silicon carbide, which is extremely scratch resistant, but is also brittle and may break if dropped.

CAUTION
The piston is quite brittle, and therefore should never be dropped or handled roughly. Be extremely careful when handling the piston.

The Q6000 pump cylinder must be at the "Max (maximum) Extend" motion status prior to installing the piston. New pump cylinders shipped from Chandler Engineering are at the "Max Extend" position. Look at the PumpWorks main window and confirm that the motion status display shows "Max Extend". If not, use the directions in Section 2.11 to move the pump cylinder until it is at "Max Extend".

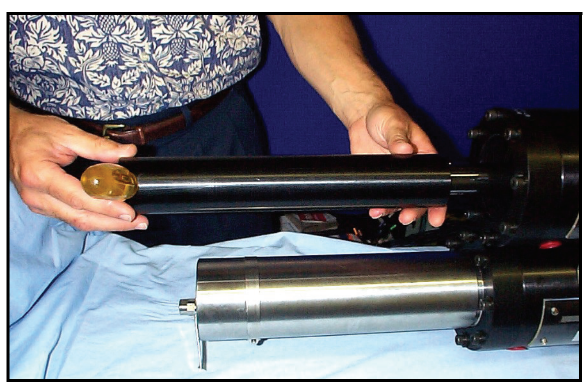


Figure 2-15

1. To install the piston, use the piston insertion tool and spanner wrench. Locate these in the Special Tool Kit shipped with your system. See Page 11-1 for a picture of these tools.

Each piston shipped with your system consists of the Silicon Carbide piston itself and the attached metal piston holder, which has threads inside it. Screw the piston holder onto the threads at the end of the ball screw (inside the main cylinder housing). Hand tighten the piston.

2. Use the piston insertion tool to tighten the piston. Insert the two metal dowel pins into the corresponding holes on the piston holder; the dowel pins will seat into these holes. Then, insert the adjustable spanner wrench into the holes of the piston insertion tool and tighten it until it is secure.

3. Repeat this process for each pump cylinder in your system.

If the piston is not screwed into the ball screw tight enough, it will unscrew with the cylinder barrel when the cylinder barrel is unscrewed. Of course, you do not want to excessively over-tighten the piston either, as this will make it difficult to remove at a later time.

2.11 Installing the Cylinder Barrel

The next step in the system setup process is to install the cylinder barrel, which the piston will move in and out of when the pump is running. In order to install the cylinder barrel, the piston must first be moved from its Max Extend position to its Max Retract position. At this point, it is assumed that the user has completed the following:

IMPORTANT
If the piston is not a the Max Retract position, the piston can be broken during installation.

- All cables have been connected
- The motor driver on the pump cylinder is turned on (black rocker switch on top of driver).
- The CN-6000 Pump Controller is turned on, and
- The computer is turned on and PumpWorks is operating.

1. Set the Safety Pressure for pump cylinder 1A to 100 PSI (700 kPa) by doing the following:
   - From the menu bar select Main | Set Pump Safety Pressure.
   - In the Enter New Pressure text box of pump cylinder 1A, enter 100 for PSI (700 for kPa).
   - Click on “Send Safety Pressures to Pump(s)”.

2. Set the Operating Mode to Mode 1, which is Independent Constant Rate. To set the operating mode:
   - Click on the “Operating Mode” button in the main window and a list of operating modes will appear.

- Click on Independent Constant Rate Operation, mode number 1, for pump cylinder 1A.

3. Set the Flow Rate at approximately 25% of the maximum allowable flow rate. The maximum pump cylinder flow rate is displayed in the Set Flow Rate box of the main window. At the rates shown below, a full piston stroke takes about 5-1/2 minutes. To change the Flow Rate:
   - From the menu bar select Main | Set Pump Flow Rates.
   - In the Enter New Flow Rate text box enter:
     100 ml/min for the Q6000-5K or
     50 ml/min for the Q6000-10K.
     25 ml/min for the Q6000-20K
   - Click on “Send Rates to Pump(s)”.

4. Set the direction to Retract for each pump cylinder. To do this, click on the Cylinder Direction button on the main window and enter "retract".

5. The valves are not functioning at the point in the installation. Instruction will be given in the next chapter on installing the valves.

6. Start pump cylinder 1A by clicking on the “Press to Start” button. Watch and listen for proper operation. Watch the Piston Position display on the monitor. It should show that the piston is moving. Listen for the sound of the pump cylinder running and then stopping. This is a low level sound which can be heard if you are in a quiet work area.

   When the piston reaches the end of its stroke, it automatically stops and displays Max Retract in the Motion Status box.

Figure 2-16

7. Carefully pick up the cylinder barrel and align with the threads on the pump housing. Screw the cylinder barrel back into the pump. Do not allow the weight of the cylinder barrel to press down on the piston or the piston may break.

8. Screw the cylinder barrel down until it is seated against the pump housing. When properly seated, the fluid inlet port (to which the valves will be attached) should be the top hole when you look at the end of the cylinder barrel. (See Figure 2-19 on the following page.)

9. Repeat this process for each pump cylinder in your system.

2.12 Installing the Valves and Transducers

Refer to Table 11-1 on page 11-1 to see the tools included with your system that will help you with the next steps. The 5/8" angled open-end wrench is used to tighten the Speedbite fittings and is especially useful for tightening the ports on the cylinder barrel. The 22 mm open-end wrench is used to hold the pressure transducer in place while tightening the fluid fittings

2.12.1 Q6000-5K and 10K Pump Systems

1. Refer to the Figure 2-19 which shows the three holes at the front of the cylinder barrel (for Q6000-5K and Q6000-10K models). The top hole is the fluid inlet/outlet port of the pump cylinder, where the valve tubing should be installed.

   The valves use a 3-way, T-formation design, so that within each CV valve there is a fill valve that controls the flow of fluid into the pump cylinder and a deliver valve that controls the flow of fluid out of the pump cylinder. Each valve has an inlet tube at one end, an outlet tube at the other end, and a tube that leads to the center port of the valve and connects to the pump cylinder.

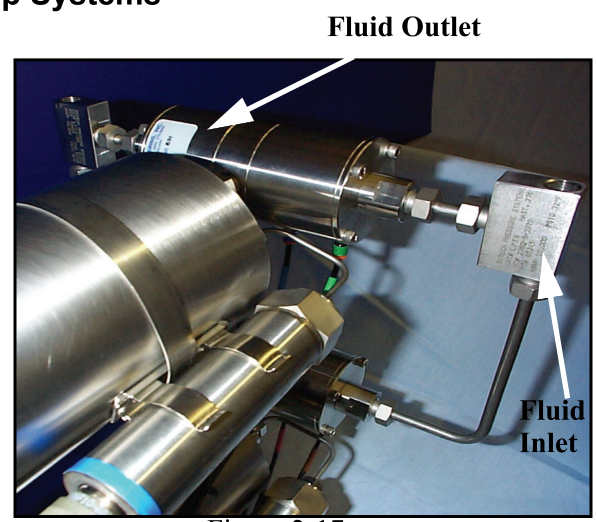


Figure 2-17

.

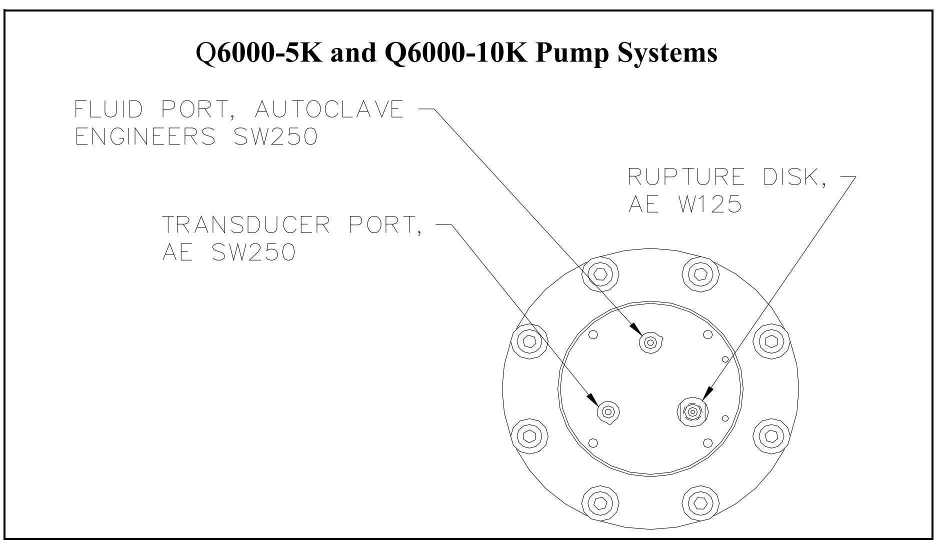


Figure 2-18 Front of Cylinder Barrel

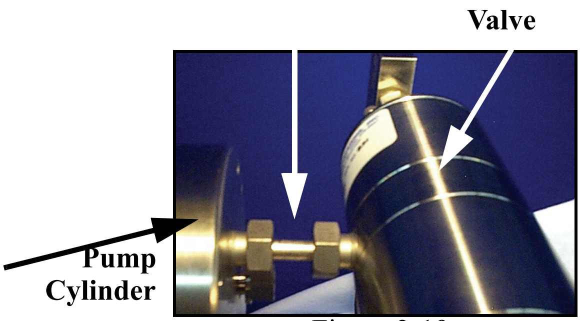


Figure 2-19

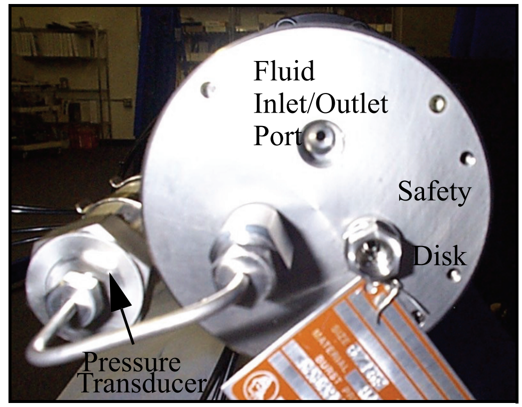


Figure 2-20

2. Install the tubing from the center port of the valve into the fluid inlet/outlet port with the tube that is attached to the valve. The valve will extend out from the end of the cylinder barrel. Refer to Figure 2-20. Repeat for each pump cylinder in your system.

3. Install the tubing from the pressure transducer into the lower left hole at the end of the cylinder barrel. See Figure 2-21. For ambient temperature systems, mount the transducer to the side of the cylinder barrel. For high temperature systems, the transducer must be placed outside the oven if the temperature will exceed 80 degrees C.

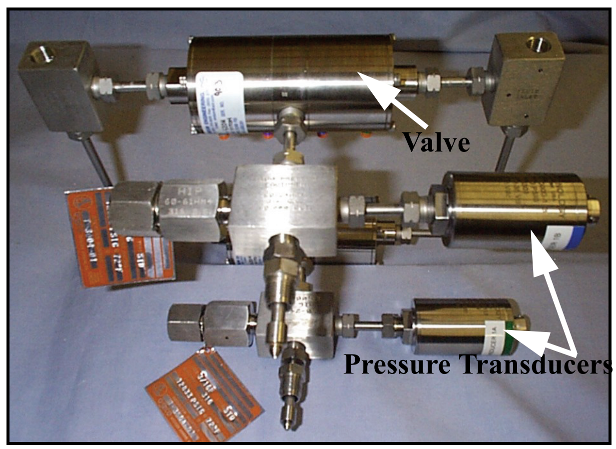


Figure 2-21

4. The third hole at the end of the cylinder barrel has a safety rupture disk installed. There will be a tag indicating the specifications of the safety rupture disk. See Section 5.3.4 for more information on this important safety feature.

2.12.2 Q6000-20K Pump Systems

For the Q6000-20K pump systems the pump cylinders are designed for a maximum pressure of 20,000 psi and have only one port at the end of the cylinder barrel. The tubing from this port attaches to a cross (a 4-holed tee). From the cross, attach tubing to connect to (1) the valve, (2) the pressure transducer, and (3) the safety rupture disk assembly.

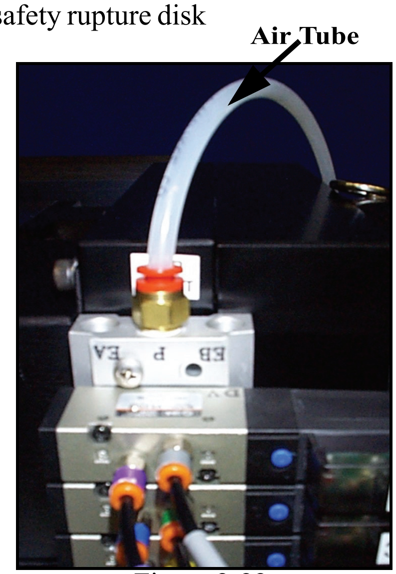


Figure 2-22

The Valve Assembly for the 20K Pump System will be shipped in a separate, cardboard box and will include the valves, pressure transducers, safety burst disks and cross already connected.

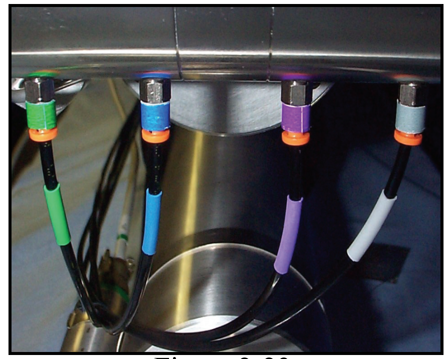


Figure 2-23

2.13 Connecting the Air Supply

The valves used in the 6000 Series Pump System are air actuated. Air is taken into the system at the pilot solenoid manifold, then air tubes connect the pilot solenoids and the valves. The air inlet fitting at the pilot solenoid manifold, which is labeled "P", has a 1/4" quick-disconnect fitting. You should insert a 1/4" tube into this fitting to connect the pump system with a pressurized air source.

A standard laboratory air supply, or an air compressor, may be used. The air should be clean, dry, oil-free, and regulated at 85-115 psi (600-800kPa).

The air tubing between the pilot solenoids and the valves is color-coded at both ends. Match each end carefully. For example, the pilot solenoid fitting with the orange band should match the tubing with the orange band.

2.14 Connecting Your Fluid Plumbing

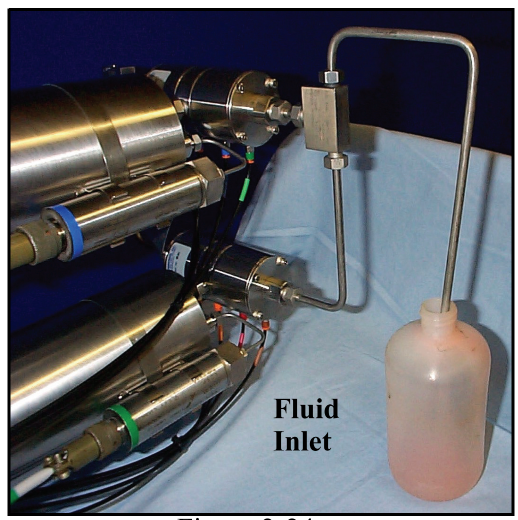


Figure 2-24

The final step in setting up your 6000 Series Pump System is connecting the fluid plumbing. All of the tubing that has been provided with your system is either stainless steel (SS-316) or Hastelloy (C-276) 1/4" tubing, except the tubing for the pressure transducer connections, which is 1/8". The user will need to supply tubing to the fluid inlet tee and from the fluid outlet tee. Nuts & ferrules for both of these fittings are provided in the installation kit.

1. There is one fluid inlet tee for each pair of pump cylinders in your system. From the fluid inlet tee, a section of tubing connects to the fill side of each valve in the cylinder pair. The user will need to connect a section of 1/4" tubing from the fluid source to the fluid inlet tee.

2. There is one fluid outlet tee for each pair of pump cylinders in your system. From the fluid outlet tee, a section of tubing connects to the deliver side of each valve in the cylinder pair. The user will need to connect a section of 1/4" tubing from the fluid outlet tee to their experiment. Refer to Appendix A for Speedbite installation instructions.

3. Install tubing from the safety rupture disk port to an appropriate container to prevent fluid from suddenly spraying into the atmosphere if the safety rupture disk is activated. The fluid exit port is fitted with an Autoclave 1/8" Speedbite Fitting so that tubing can be attached to vent fluid to a container.

4. Carefully check that all fittings are tightened. If fittings are not tight, leaks can occur. The pump system is fluid-tight at the time it is shipped. However, Chandler Engineering recommends that you carefully check all the fittings prior to operation and use the open-end wrench supplied in the Special tool Kit (see page 11-1). Most pump system leaks can be traced to fittings.

The 6000 Series Pump System has now been set up and the user should proceed immediately to the "System Checkout And Operation" in Chapter 3.

2.15 Setting Up a High Temperature System: Oven Installation

The 6000 Series Pump System is available in a high temperature version to allow fluid delivery at reservoir temperatures. When installing a high temperature system into an oven, follow these guidelines for each component.

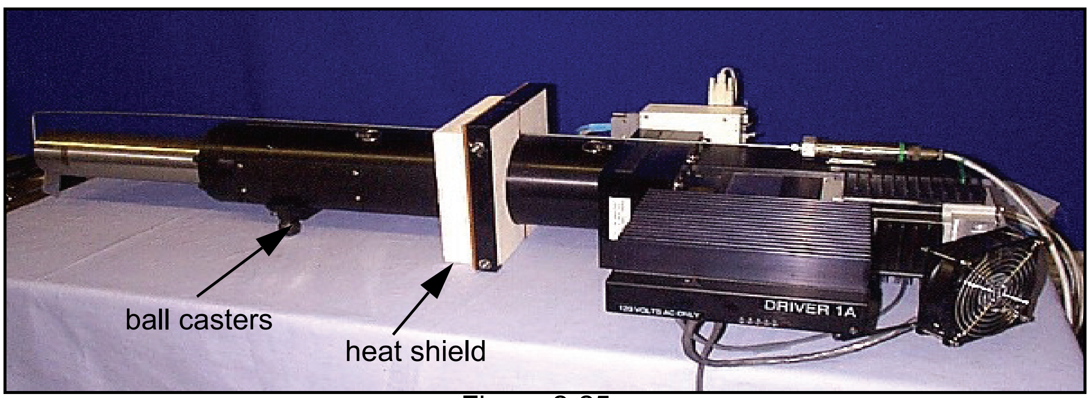


Figure 2-25

Pump Cylinders: The pump cylinder must be placed in the oven so that the main housing tube extends through the oven wall, with the entire motor and fan cooling assembly residing outside of the oven. Generally, one hole must be cut in the oven wall for each pump cylinder.

Pressure Transducers: The standard pressure transducers supplied with the system are designed for operation up to 70°C. They can be used at temperatures up to 80°C inside of an oven without severely shortening their lifetime. However, for temperatures above 80°C, the pressure transducers must be mounted outside of the oven.

Valves: A high temperature version of the valve is available that can be heated to 160°C. The pilot solenoids, however, cannot be placed in an oven. The pilot solenoids should be placed outside of the oven with air tubes connecting the pilot solenoids and the valves, using high temperature tubing (Teflon®) and compression fittings.

For oven–mounted systems, the location of the pump cylinders, pump controller, pressure transducers, and pilot solenoid manifold determines the length of each cable. Chandler Engineering supplies cables to user–specified lengths for most high temperature systems. If a cable is not long enough for your application, consult Table 2-1.

Table 2-1. Cabling Chart

Cable Label	Connection	Remedy
driver cable	pump cylinder to pump controller	Order a driver cable extension 2 meters long. Note: If possible, avoid this extension because of high frequency signals.
sensor cable	pump cylinder to pump controller	Order the correct length.
valve cable and transducer cable	pump controller to pilot solenoid manifold and pump controller to pressure transducers	Order the correct length for all solenoids and pressure transducers. Note: If possible, avoid long cables to reduce extraneous noise
data cable	pump controller to serial expander/isolator	Order the correct length.
RS–232 cable	serial expander/isolator to computer	Available at computer stores as a 9–pin male–to–female RS–232 cable.

For more information about the differences between the standard and high temperature versions of each component see Pump Cylinder High Temperature Option, Section 7.7 and High Temperature Option, Section 8.7. For a full description of all valves, plumbing and cables to be connected, see Chapter 8, "Valves and Plumbing" and Chapter 9, "System Cables".

3 System Checkout And Operation

Chapter 3 provides important checkout procedures designed to help ensure the safe operation of your 6000 Series Pump System. Included in this chapter are the following:

- When To Perform The System Checkout, Section 3.1
- Verification of All Cable and Plumbing Connections, Section 3.2
- Valve Check, Section 3.3
- Pump Cylinder Check, Section 3.4
- Filling the System with Liquid, Section 3.5
- Pressure Transducer Check, Section 3.6

For detailed instructions on operation of the software, refer to the PumpWorks User's Manual. A detailed description of the safety features included with the Quizix pump system is provided in Chapter 5.

IMPORTANT
Safety procedures are essential to safe operation of the Quizix pump system. Follow them carefully.

Because of the high pressures achieved by Quizix pumps, the importance of the system checkout as a safety procedure cannot be over-emphasized. If the check-out procedure is followed, the 6000 Series Pump System is designed to operate safely. As with most machinery, system safety depends on following proper operating procedures. Carelessness can be dangerous!

3.1 When To Perform The System Checkout

You should perform the System Checkout in each of the following situations:

- **When the system is first received from Chandler Engineering.**
  Although all systems are carefully checked before shipment, it is necessary to ensure that no damage occurred during shipment and that the pump system has been properly assembled.

- **After any changes are made to any of the pump system's components or plumbing.**

- **After moving the system, reconfiguring it (adding or removing pumps), or making any other adjustments** that require you to disconnect, then reconnect the cables or plumbing.

- **If the system has not been operated for more than three months.**

3.2 Verification of All Cable and Plumbing Connections

It is absolutely essential that all cable and plumbing connections are made correctly. The system can seriously malfunction if cables are switched or fluid plumbing is connected improperly.

The software can detect if all cables are connected, but it cannot determine if they are connected in the right places. For example, if the driver cable from cylinder A is plugged into the connector for cylinder B and the driver cable for cylinder B is plugged into the connector for cylinder A, the system will not operate properly. It could generate high pressures, resulting in the rupture of the safety rupture disk. As another example, if the valve cable labeled 5 is plugged into solenoid 6, the system would not operate properly. Only a careful and thorough visual check can prevent this situation.

IMPORTANT
It is strongly recommended that you carefully double–check all the cable and plumbing connections each time you disconnect, then reconnect them. After double checking your connections, complete the system checkout before operating your pump.

3.2.1 Connection Checklist

The purpose of this safety check is to make sure that all the cables and fluid plumbing are connected to the proper components. All plumbing and cables are labeled and many are color-coded.

1. **Driver Control Cables – From the Pump Controller to the Motor Drivers**
   Make sure each cable from EACH motor driver is plugged into the correct connector on the CN-6000 Pump Controller for that pump cylinder. That is, Driver A into the receptacle labeled “Driver A” on controller, and Driver B into the receptacle labeled “Driver B” on interface box 2.

2. **Sensor Cables – From Interface Box to Cylinder Sensors**
   Make sure EACH Q6000 sensor cable is plugged into the correct connector on the CN-6000 Pump Controller. For example, Sensor A is plugged into the receptacle labeled “Sensor A” on the controller.

3. **Transducer and Valve Cable – From Pump Controller to the Pilot Solenoids and Pressure Transducers**
   Make sure each numbered cable branch is plugged into the pilot solenoid with the same number. For example, cable branch 1 into pilot solenoid 1. Also make sure each numbered cable branch is plugged into the pressure transducer with the same number. For example, cable branch A into pressure transducer A mounted on pump cylinder A.

4. **Data Cable – From Pump Controller To Serial Expander/Isolator**
   Make sure the data cable from the pump controller is connected to Port A of the Serial Expander/Isolator. If you have two pump controllers, the second one's data cable should be connected to Port B.

5. **RS–232 Cable – From Pump Controller To Computer**

6. **Color–Coded Air Tubing–from Pilot Solenoids To Valves**
   At both the pilot solenoid end and the valve end, check to ensure that the color coding matches. For example, the pilot solenoid fitting with the orange band should match the tubing with the orange band.

7. **Fluid Plumbing (Q6105 and Q6110)**
   Make sure the tubing from the center port of each valve goes to the top hole on the end of the cylinder barrel. The tubing from the pressure transducer connects to the lower fitting on the end of the cylinder barrel. Trace all plumbing connections to make sure the plumbing is complete and fittings are properly tightened. Connect tubing to the port of the safety rupture disk for fluid release in case the safety rupture disk ruptures.

8. **Fluid Plumbing (Q6120)**
   Make sure the tubing that extends from the port at the end of the cylinder barrel connects to a cross (a 4-holed tee). From the cross, tubing should connect to (1) the center port of the valve, (2) the pressure transducer and (3) the safety rupture disk assembly. Connect tubing to the port of the rupture disk assembly in case the safety rupture disk ruptures. Make sure all fittings are properly tightened.

9. **Fluid Inlet and Outlets**
   Be sure to connect your fluid source to the fitting labeled "fluid inlet". The output of the pump is available through the fluid outlet line.

3.3 Valve Check

Ensure that the valves are working properly by conducting a visual and auditory check. There is a small red indicator light on each pilot solenoid. The light is ON when the corresponding valve is open; the light is OFF when the corresponding valve is closed.

1. Turn on the computer and the pump controller. Connect the compressed air supply to the pilot solenoid manifold. It is assumed that PumpWorks is installed on your computer already and is running.

2. Use the Pump Data & Controls window in PumpWorks to open and close each pump cylinder's fill and deliver valves. Begin by selecting the fill valve for pump cylinder 1A; click on its button to open and close it.

   - Verify that the light on the pilot solenoid labeled "1" is OFF when pump cylinder A's fill valve is closed. Open this valve and verify that the light for pilot solenoid 1 goes ON. Also, listen for a "popping" sound as the valve opens and closes.

- If the light goes ON and OFF for a different pilot solenoid than the one you are controlling on the computer, the valve cables are switched and must be reconnected properly.
- If the light does not go ON or OFF, either the pump controller or the pilot solenoid is malfunctioning.
- If you do not hear a distinct popping sound when each valve opens and closes, then there is not adequate air pressure to operate the valves. Check the tubing from the pilot solenoids to the valves and check your pressurized air supply.

3. Repeat this procedure for pump cylinder 1A's deliver valve and for each of the fill and deliver valves in your system.

3.4 Pump Cylinder Check

This safety check involves running each pump cylinder manually through one full piston stroke (extend and retract) and watching the piston move. Ideally, this test should be run with no liquid in the system. Unless the pumps are already filled with liquid, just use air. If the pumps already contain liquid, you can proceed with the test, but, be aware that with liquids pressures can rise rapidly when the pump cylinders are extending.

1. It is assumed that you have just completed the valve check described in the previous section and you have PumpWorks turned on. Set the safety pressure for the pump cylinders you are testing to 100 psi (700 kPa) using the Main -> Set Pump Safety Pressure window.

2. Set the Operating Mode to Mode 1, which is the Independent Constant Rate mode.

3. Set the Flow Rate at approximately 40% of the maximum allowable flow rate (40 ml/min for a Q6120, 80 ml/min for a Q6110 and 160 ml/min for a Q6105). The maximum pump cylinder rate is displayed in the software in the Set Flow Rate window. At this rate, (40% of maximum), a full piston stroke takes a little over three minutes.

4. If you have just completed the system setup directions in Chapter 2, it is assumed that the motion status of each piston is "Max Retract". If so, set the direction to Extend for each pump cylinder. If not, set the direction to Retract first, until it reaches Max Retract, and then Extend.

5. Set the valves so that the air or liquid displaced will not build up pressure. Usually, this means opening all fill valves. Deliver valves may also be opened.

6. Start pump cylinder 1A by pressing the "Press to Start" button. View pump cylinder 1A through the side cover to see the piston move. Ensure that the pump cylinder labeled "Cylinder 1A" is actually the pump cylinder in which the piston is moving. If a different pump cylinder operates when you press the "Press to Start" button for cylinder 1A, then a cable connection is wired improperly and must be corrected.

NOTE: On ambient temperature systems, the piston can be viewed through the plastic side covers on the pump cylinder. On high temperature systems, the piston can be viewed through the slot in the metal side cover.

7. When the piston reaches the end of its stroke, it automatically stops and displays Max Extend as the position. The direction automatically switches from Extend to Retract. Start the pump cylinder again and view the piston through the side cover until it reaches its Max Retract position. Also, listen for the sound of the motor running and then stopping. You should also ensure that the fan is operating.

8. Repeat this procedure for each pump cylinder. Set the direction to Extend for one piston stroke, then Retract for one stroke. Look and listen to each piston stroke for correct operation.

   This check indicates that the software, pump controller, motor driver, and limit switches in the pump cylinder are all working properly, and the system is cabled correctly. If you do not see the piston moving in the correct pump cylinder, or hear the motor running each time, you must do additional troubleshooting. Do not proceed further until your system has passed this check.

3.5 Filling the System with Liquid

If your system does not have liquid in it, add it at this point. Connect the fluid inlet tubing to a fluid supply and the fluid outlet tubing to a drain. Fill each pump cylinder manually by using PumpWorks and the following procedure.

1. To fill a pump cylinder with fluid, leave the safety pressure at 100 psi (700 kPa) and set the flow rate to about 100 ml/min (for Q6105 and Q6110 models.) For Q6120 models, set the flow rate to 50 ml/min.)

2. Open the deliver valve, close the fill valve, set the direction to Extend, and start pump cylinder 1A. Place the end of the fluid outlet tubing into a container of liquid and watch for air bubbles as the piston extends and air is pushed out of the cylinder barrel.

3. When the pump cylinder reaches the Max Extend position, close the deliver valve, open the fill valve, switch the direction to Retract. Re-start the pump cylinder, and as the piston retracts, fluid will be drawn into the cylinder barrel. Then, on the next Extend stroke, mostly air is still delivered out of the fluid outlet fitting. If neither air nor fluid is delivered out of the fluid outlet, there is probably a leak in the plumbing.

4. Repeat this procedure until you reach a piston stroke where no air bubbles come out, only liquid. End with a Retract stroke. The cylinder barrel is now full of fluid and all air is flushed out. (If you are pumping gas, test for bubbles.)

5. Repeat this procedure for each pump cylinder in your system, ending with all pump cylinders full of fluid and the pistons in the Max Retract position.

3.6 Pressure Transducer Check

Because the pump system can reach extremely high pressures very quickly, it is absolutely essential that the pressure transducers be checked carefully. To do this, use the following procedure.

1. It is assumed that each pump cylinder is full of fluid and each piston is in the Max Retract position. Close both valves (fill and deliver) for pump cylinder 1A using PumpWorks Pump Data & Controls window.

2. Set the flow rate to 10 ml/min.

3. With the safety pressure still set at 100 psi (700 kPa), and the direction set to Extend, start the pump cylinder. Watch the current pressure reading until it exceeds 100 psi (700 kPa) and is stopped by the digital overpressure control system. If the pump cylinders are filled with liquid, this should occur with less than 3 ml of fluid displaced within the cylinder barrel. If you are pumping gas, it will take longer to reach the safety pressure of 100 psi.

4. **Stop the pump cylinder if**:

   - **The pressure reading does not stop increasing when it reaches 100 psi (700 kPa)** You must do further troubleshooting due to an apparent pressure transducer or pump controller malfunction. The likely cause of this is either the pressure transducer or the motor is cross wired. For example, pump cylinder 1A's pressure transducer may be connected to pump cylinder 1B's connector.

   - **The pressure reading does not begin to increase after about 30 seconds.** The most likely cause of this problem is there is no fluid in the pump, which can be caused by:

     - an air leak in the fluid tubing allowing air to enter the pump system.
     - the fluid inlet tubing being clogged, preventing fluid flow in the tubing.
     - fluid being too viscous, or thick, to be pulled into the pump.

     It is a good idea, at this time, to go through the pump and check all fluid fitting connections to make sure they are tight.

     Another possible cause is either the pressure transducer is broken and not reporting the pressure, or the pressure transducer is cross-wired. Open the fill valve and listen for pressure being released. If there is pressure being released, you probably have a pressure transducer failure or the pressure transducer is cross-wired.

CAUTION
NEVER operate the system AT ALL if you have any reason to believe a transducer has failed.

5. Repeat the Pressure Transducer Check for each pump cylinder in your system.

Do not proceed further until your system has passed all checks.

After completing each of the above checks, you can proceed to operate the system. Remember, however, that if you disconnect any of the major components, reconfigure the system, change the plumbing, or make any other adjustments that involve disconnecting and reconnecting any of the cables or plumbing, you need to do each of these safety procedures again.

This page intentionally left blank.

4 Pump Operating Basics

For instructions on the basis of operating your 6000 Series Pump System using PumpWorks© Software, please refer to the PumpWorks User's Manual.

This page is intentionally left blank.

5 Safety Features

Quizix pump systems are capable of creating and maintaining very high pressures. Safe operation of these systems is a primary concern. The safety features described in this chapter are designed into all Quizix pump systems and include the following:

- Cable Connections Sensing, Section 5.1
- Cable Labeling, Section 5.2
- Overpressure Protection Safety Features, Section 5.3
- Emergency Stop Capability, Section 5.4

5.1 Cable Connections Sensing

To verify that all major components are present before a pump system can be operated, PumpWorks includes a feature that detects the connection of the following four cables:

- Transducer and valve cable (pressure transducers and valve solenoids to CN-6000 Pump Controller)
- Driver cable (motor driver to CN-6000 Pump Controller)
- Sensor cable (sensor board to CN-6000 Pump Controller)
- Data cable (CN-6000 Pump Controller to serial expander/isolator)

If a connection is not detected, an error message is displayed on the system monitor and the pump cylinders stop operating. It is important to note that the cable connection sensing feature can only detect the presence of a cable; it cannot detect if it is the correct cable where more than one of a certain type of cable may be connected. For example, if the driver cables are reversed (that is, the driver cable from pump cylinder A is plugged into the receptacle for pump cylinder B, and vice versa), PumpWorks cannot detect the problem. This is why it is of the utmost importance to always carefully check cable connections as described in Chapter 3.

5.2 Cable Labeling

Chandler Engineering labels all cables at both ends and labels the device to which they connect with unique label names. Color–coding is also used to simplify the identification of proper connector locations.

⚠ IMPORTANT
All cables are uniquely labeled and color–coded. It is important that components be mounted in their correct locations, where all cable markings match.

5.3 Overpressure Protection Safety Features

To prevent the pump system from reaching excessively high pressures, multiple safety features are implemented. They are described in this section.

5.3.1 Digital Overpressure

The most basic of these safety features is digital overpressure, which is monitored in the pump controller software. With this feature, the user specifies a safety pressure at a level higher than the expected running pressure. If the system exceeds the safety pressure setting, a Digital Overpressure error message is displayed on the system monitor and the pump cylinders stop pumping. The pump controller stops the pump when the safety pressure is reached. Due to momentum, if the piston is moving forward at a fast rate when overpressure is detected, the system pressure may exceed the safety pressure before the pump cylinder comes to a complete stop.

5.3.2 Digital Underpressure

The pressure transducer for the 6000 Series Pump System has been selected so that at zero pressure, the pressure transducer output is 0.5 volts. The pump controller includes a safety feature that provides an error message if the pressure transducer voltage drops below a certain level, or pressure signals are not received by the pump controller. In this case, the software assumes that there is a pressure transducer failure. A Digital Underpressure error message is displayed and the pump cylinders stop pumping.

5.3.3 Analog Overpressure

The analog overpressure feature is implemented in the pump controller and limits the maximum value allowed from the A/D converter. The analog overpressure feature is fixed at approximately 5% over the maximum pressure specification of the pump system. It cannot be set by the user. If an analog overpressure error occurs, the pump cylinders stop pumping and an error message is displayed.

5.3.4 Safety Rupture Disk

The final safety feature designed to prevent excessive pressures is the safety rupture disk. Safety rupture disks are installed to prevent the system from exceeding a specified pressure. (For systems rated at 10,000 psi, the safety rupture disk activates at approximately 12,500 psi.) The safety rupture disk is activated if there is a pressure transducer failure that cannot be detected by the normal safety systems. It is also activated in the unlikely event of a hardware or software failure where the system does not respond to normal controls. In this case, the safety rupture disk protects the pump, tubing, and external components from damage due to excessive high pressures.

.

Model	Maximum Pressure of Pump	Safety Rupture Disk Activation Pressure
Q6105	5,000 psi	6,500 psi
Q6110	10,000 psi	12,750 psi
Q6120	20,000 psi	25,000 psi

IMPORTANT

It is very important that the you install tubing into the fitting of the fluid outlet and that it is plumbed to an appropriate receptacle. This prevents fluid from spraying into the atmosphere in case the safety rupture disk is activated. This is particularly important if you are using flammable or highly corrosive fluids.

5.3.4.1 Q6105 and Q6110 Pump Cylinders

The safety rupture disk for the Q6105 and Q6110 models, shown in Figure 5-1, is a round metal component that is located inside the pump cylinder. The safety rupture disk is a Fike 3/16” rupture disk that is held in place by a compression ring and locking fitting. If the specified pressure is exceeded, the safety rupture disk ruptures and fluid is expelled through the fluid outlet. The fluid outlet port is fitted with an Autoclave W125 (1/8" speedbite) fitting. The user can attach tubing to this fitting and vent the fluid to a harmless location.

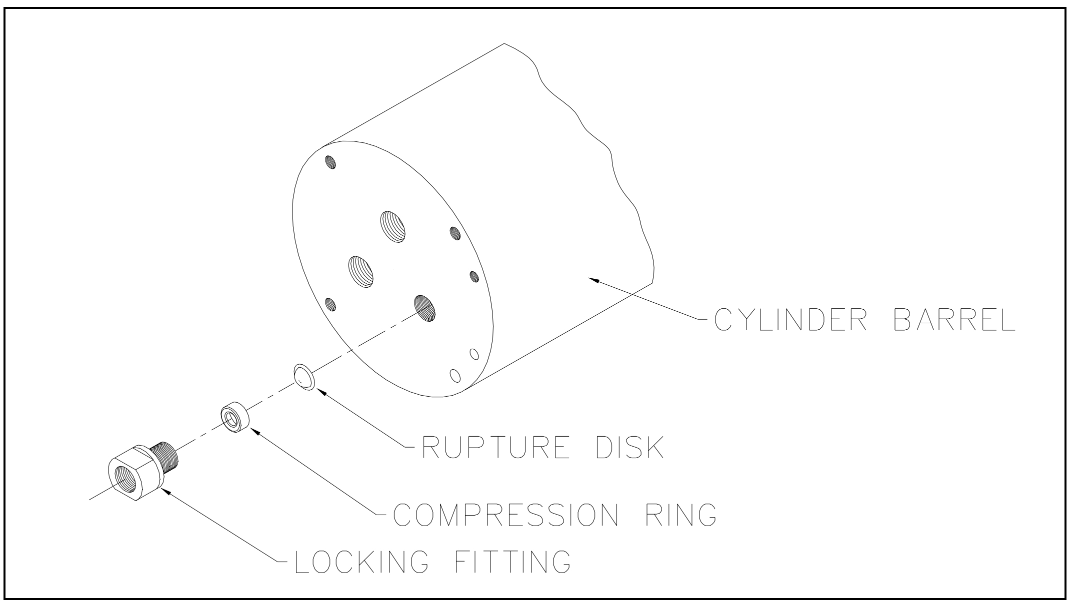


Figure 5-1 Q6105 and Q6110 Safety Rupture Disk

5.3.4.2 Q6120 Pump Cylinder

The safety rupture disk for the Q6120 model is located in a separate safety disk holder that is part of the fluid plumbing. If the specified pressure is exceeded, the safety rupture disk ruptures and fluid is expelled through the fluid outlet. The fluid outlet port should be plumbed by the user to vent to a harmless location.

5.3.4.3 All Q6000 Pump Cylinder Models

Each safety rupture disk is shipped with a tag that shows the specified pressure level at which it will activate. To operate properly, the retaining fitting must be torqued properly (for a 12,750 psi disk, the torque is specified at 45 ft–lbs, or 61 Newton meters). If you unscrew the locking fitting in the vent port, make sure to screw it back to the specified torque level. See Chapter 11.

If you regularly operate your pump system at pressures in the range of 80 to 100% of maximum pressure, note that safety rupture disks can weaken after extended use at these pressures. If you frequently operate at such high pressures, you should replace the safety rupture disks on a regular basis as part of the scheduled system maintenance. Alternatively, you may want to install safety rupture disks with a higher rating. In that case, contact Chandler Engineering for the appropriate specifications.

The safety rupture disk included in all Quizix pump systems is a ONE–TIME ONLY item that must be replaced if it is activated. It is not a pressure relief valve and cannot be tested. If you bring the system pressure up to the level at which the disk is designed to activate, it will break and must be replaced.

To replace a safety rupture disk, follow the instructions in Chapter 11.

5.4 Emergency Stop Capability

The CN-6000 Pump Controller includes an emergency stop capability, which is accessed through the User Interface connector. If you would like to implement an emergency stop function for your pump system, you will need to install a User Interface cable.

Pin 19 of the user interface connector is tied to the emergency stop signal of the pump controller. By setting a jumper inside the controller, this line can be made to be: 1) a pull to ground for emergency stop, or 2) a loop signal which, if it is interrupted, causes an emergency stop. For more information, See Appendix C of the PumpWorks Manual.

6 CN-6000 Pump Controller

The CN-6000 Pump Controller controls the operation of the entire 6000 Series Pump System. The pump controller operates the system according to the settings used in PumpWorks. It coordinates all system components and maintains the safety and integrity of the system.

The CN-6000 Pump Controller is a 2-channel unit and can control two Q6000 pump cylinders. Pump systems with three or four pump cylinders will include two pump controllers. Pump systems with five or six pump cylinders will include three pump controllers.

The CN-6000 can also be used with a 5000 Series Pump System, as an upgrade for the earlier generation of Quizix pump controller, the SC-2400 Pump Controller. When used with 5000 Series pump cylinders, the system must also include a SC-220 Motor Driver.

The CN-6000 pump controller performs the following specific functions:

- Controls pump cylinders through real–time control of the rate and direction of the stepper motors.
- Controls the operation of the valves.
- Monitors fluid pressure, as measured by the pressure transducers.
- Monitors safety shutdowns, such as when a safety pressure error occurs.
- Monitors the fluid volume and position of the piston in each pump cylinder.
- Monitors system status, such as cable connections, power turned on, etc.
- Monitors any analog signal inputs that may be added to the system, such as other pressures or temperatures.
- Communicates with PumpWorks to translate user commands into actual pump operation.
- Transfers system data back to PumpWorks for viewing and, if desired, recording data in a software data log.
- Provides signal conditioning for analog transducers so that they can be calibrated.
- Executes rate ramping and valve operations during switch–over from one pump cylinder to another.
- When required, executes pressure control algorithms, to maintain a specified pressure level.

This chapter also discusses the serial expander/isolator, which must be used in conjunction with the CN-6000 Pump Controller.

6.1 Pump Controller On/Off Switch and Label

The CN-6000 Pump Controller measures 17 x 13 x 5 centimeters (approximately 6-1/2 x 5 x 2 inches). The front of the CN-6000 is shown in Figure 6-1.

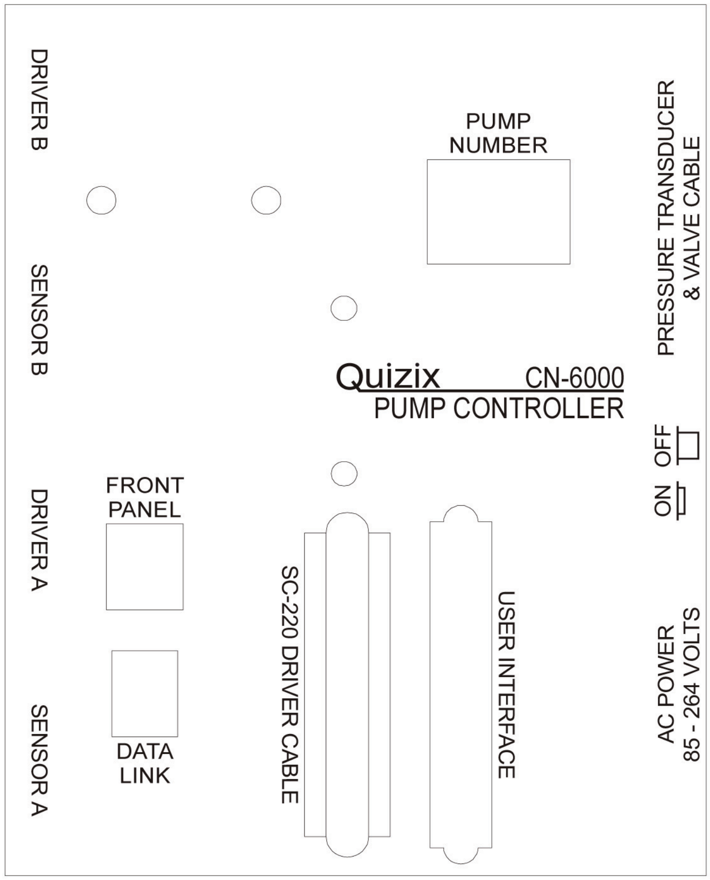


Figure 6-1 CN-6000 Pump Controller

The On/Off switch is a red button on the right side of the controller. Press it in to turn on the controller. When the CN-6000 Pump Controller is turned on, a sequence of diagnostic tests is run, as shown on the two-digit display labeled “Pump Number”.

In general, the user should install all cable connections and have PumpWorks running on their computer BEFORE turning on the controller. Watch the two-digit display when the controller is turned on; see Section 2.7 for important information on this feature.

⚠ WARNING
THE PUMP CONTROLLER SHOULD BE TURNED OFF BEFORE CONNECTING OR DISCONNECTING ANY OF THE CABLES.

The label affixed to each CN-6000 provides the serial number of the pump controller.

6.2 Cable Connections

6.2.1 Driver Cable

The Driver Cable connects the CN-6000 Pump Controller with the motor driver attached to each Q6000 pump cylinder. Each pump controller includes two 9-pin, D-style connectors for driver cables, labeled “Driver A” and “Driver B”. If the controller is used with only one pump cylinder, the “Driver B” connector will not be used.

6.2.2 Sensor Cable

The Sensor Cable connects the CN-6000 Pump Controller with the sensor boards of each 6000 Series pump cylinder. The purpose of the sensor board is to detect the position of the piston within the cylinder barrel. Each pump controller includes two 14-pin, ribbon-style connectors for the sensor cables, labeled “Sensor A” and Sensor B”. If the controller is used with only one pump cylinder, the “Sensor B” connector will not be used.

6.2.3 Transducer and Valve Cable

The Transducer and Valve Cable connects the CN-6000 Pump Controller with both the pressure transducers and the pilot solenoids for the valves. This cable has a 25-pin, D-style connector at the pump controller end, and branches out into one cable branch for each pressure transducer and one branch for each pilot solenoid. There is a 6-pin circular connector at the pressure transducer end for each branch. The branches are labeled “Transducer 1A” and “Transducer 1B”. If there are two controllers, the branches on the second controller will read “Transducer 2A” and “Transducer 2B”.

This cable also branches into wires that are connected to the pilot solenoids with 2-pin connectors. The wires are numbered and must be connected in the proper order; for example, wire 1 into pilot solenoid 1, wire 2 into pilot solenoid 2, and so on.

6.2.4 AC Power Cord Receptacle

The CN-6000 Pump Controller has a voltage range of 110 to 120 volts, 20/60 Hz. The pump controller consumes less than 5 watts. The power cord supplied will agree with the voltage in the user’s country. The power cord should be connected to an AC power outlet, preferably by way of an uninterruptable power supply. See Chapter 10 for more information about uninterruptable power supplies.

6.2.5 Front Panel Cable

The Front Panel Cable connects the CN-6000 with the Front Control Panel, which may be used instead of PumpWorks to control the pump system. It is not available at this time.

6.2.6 Data Link Cable

The Data Link Cable connects the CN-6000 Pump Controller with the Serial Expander/ Isolator, which is typically mounted directly onto the pump controller which is used to operate cylinders 1A and 1B. If the Serial Expander/Isolator is mounted onto the pump controller, this cable is extremely short, and plugs into Port A. If your system includes two pump

controllers, there will be a longer data cable to connect the second pump controller to Port B. The Data Cable has RJ-22 connectors (phone handset-type connectors) at both ends.

6.2.7 User Interface Cable

The optional User Interface Cable allows the 6000 Series Pump System to connect to various external devices, which can be useful to the user for building a complete experimental system. Additional sensors, valves, digitally controlled devices and logic inputs, as well as power, are available on this 37-pin D-style connector. By connecting any such additional valves, digital inputs, or analog inputs (such as additional temperature or pressure transducer readings) to the CN-6000, the user will have access to them from PumpWorks. The User Interface Connector also includes an emergency stop control signal for users who want to implement an emergency stop capability for their system.

If you have a recirculating system, the User Interface Cable will be included with your system. It is used to establish communications between the controllers in recirculating systems.

6.2.8 SC-220 Driver

The optional SC-220 Driver Cable connects the CN-6000 Pump Controller with the SC-220 Dual Cylinder Driver. This cable is used **only** if the CN-6000 is used with a 5000 Series Pump System which includes a SC-220 Dual Cylinder Driver. (This situation occurs when an SC-2400 Pump Controller, which is Quizix's earlier generation controller, is upgraded with a CN-6000 Pump Controller.) The connector for this cable is a 36-pin centronics style connector.

6.2.9 RS-232 Cable

The RS-232 Cable connects the Serial Expander/Isolator with the computer. This cable has a 9-pin, D-style connector at both ends. The male end connects to the Serial Expander/Isolator port; the female end connects to one of the serial ports on the computer. You can use any serial port on your computer, but must specify which port you selected in the system communications using the Configure Pump Communications window in PumpWorks. When shipped, PumpWorks is configured for the serial expander/isolator to user Port 1.

6.3 Pump Number (Two-Digit Display)

Under the label "Pump Number" is a two-digit display, which allows the controller to communicate information to the user. Using letters, numbers, or a combination of the two, the two-digit display can convey overpressure or underpressure errors, communication errors, driver errors, or the absence of a cable. If no errors are present, the two-digit display will show the pump number (1, 2, 3, and so on). The pump number is assigned by PumpWorks based on the first available screen position, starting from left to right, on PumpWorks main window.

When turning on the pump controller, the user needs to watch the two-digit display. For more information please refer to Section 2.7, which includes a complete description of the diagnostic tests which are run when the controller is turned on.

When PumpWorks and the pump controller are communicating with each other, decimal points on the two-digit display will flash. A decimal point will flash on the right side of the right digit, which means the pump controller is sending communications to PumpWorks. A decimal point will flash on the right side of the left digit, which means that PumpWorks is sending communications to the pump controller. The right digit decimal point will flash brighter than the left digit decimal point because the pump controller has more data to send to PumpWorks than the amount of data PumpWorks has to send to the pump controller.

Refer to Chapter 12, Section 122.3.3 for more information regarding the two-digit display. Included you will find a list of error messages and how to correct them.

6.4 Serial Expander/Isolator

The serial expander/isolator (see Figure 6-2) is a device which takes one serial port of a computer and expands it into four data ports.

The serial expander/isolator is important for two main reasons. First, since computers come with a limited number of serial ports, the serial expander/isolator allows up to four dual-cylinder Quizix pumps to be connected to a single computer serial port. Therefore the user does not have to add serial ports to their computer. One computer serial port, with one serial expander/isolator connected to it, can operate any four Quizix dual-cylinder pumps.

Figure 6-2

The serial expander/isolator also serves a second purpose. It isolates the electrical signals (generated by the computer) from the data signals that go to the user's pumps. Electrical signals on the computer's RS-232 port are not connected to the electrical signals on the data port. If the user's equipment is on different electrical grounds, the serial expander/isolator prevents equipment burnout because each piece of equipment is optically isolated.

6.5 Pump Controller Subcomponents

The CN-6000 Pump Controller contains no user-serviceable parts. The user should NOT open a pump controller and attempt to service it. The Troubleshooting chapter of this manual provides details on diagnosing and resolving problems safely. If your CN-6000 is malfunctioning, it must be returned to Chandler Engineering for service.

The operation of the 6000 Series Pump System is controlled by two separate software programs:

- PumpWorks, which is stored on the user's computer, and
- The pump controller software, which is stored in the CN-6000.

New versions of both software programs are periodically released by Chandler Engineering. Problems detected after a software version is released are resolved in later versions. In order

to update the pump controller software it is NOT necessary to open the CN-6000 to change a PROM. New versions of the pump controller software code can be downloaded directly to your pump controller via PumpWorks. See Section 12.8, "Update Pump Controller Software" in the PumpWorks User's Manual for more information.

7 6000 Series Pump Cylinder & Motor Driver

This chapter describes the Q6000 pump cylinder and its motor driver. It includes:

- Q6000 Pump Cylinder, Section 7.1
- Important Operating Notes, Section 7.2
- Primary Mechanical Subcomponents of the Pump Cylinder, Section 7.3
- Pump Cylinder Barrel and Seal Assembly, Section 7.4
- Pump Cylinder Sensor Board, Section 7.5
- Pump Cylinder Hastelloy Option for Corrosive Fluids, Section 7.6
- Pump Cylinder High Temperature Option, Section 7.7
- Q6000 Pump Cylinder Motor Driver, Section 7.8

7.1 Q6000 Pump Cylinder

There are three Q6000 standard pump cylinder models that are designed for use with the 6000 Series Pump System, as shown in the following table:

Table 7-1 The 6000 Series Pump Cylinders

Model	Maximum Pressure	Maximum Pumping Rate	Piston Stroke Volume	Piston Diameter
Q6105	5,000 psi (344.7 bar)	400 ml per minute	550 ml	2.00 inch
Q6110	10,000 psi (689 bar)	200 ml per minute	275 ml	1.41 inch
Q6120	20,000 psi (1,379 bar)	100 ml per minute	135 ml	1.00 inch

*This is the typical volume pumped in a single piston stroke, if the cylinder barrel is full.

All Q6000 pump cylinders have the same basic design, only the piston diameter is different between models. The information in this chapter applies to all three of the Q6000 pump cylinder models manufactured by Chandler Engineering.

All three Q6000 cylinder models have the same basic design; only the piston diameter is different between models. The information in this chapter applies to all three of the Q6000 pump cylinder models manufactured by Chandler Engineering.

All Quizix pump cylinders are stepper motor–driven, positive–displacement pumps with precision ball screws. The basic operation of the pump cylinder is as follows:

- When the piston retracts, the pump cylinder fills with fluid through the fill side of the valve.
- With both valves closed, the piston extends slightly and pre-pressurizes the fluid.

- When the piston extends, the pump cylinder empties as fluid is pushed out of the pump cylinder and through the deliver side of the valve.

Please refer to Figure 1-1 and Figure 1-2 in Chapter 1 for mechanical drawings of the ambient temperature Q6000 pump cylinder and high temperature Q6000 pump cylinder.

The pump can operate automatically. The pump cylinder can deliver fluid continuously without user intervention. The pump can also operate manually with the user opening and closing the valve(s) and manually starting the pump after each piston stroke.

The pump system is designed to include anywhere from one to eight pump cylinders, in any configuration desired by the user. Continuous flow pumping requires two pump cylinders per fluid. Working as a coordinated pair, one pump cylinder fills and pre–pressurizes while the other pump cylinder pumps the fluid. Operated in this manner, the system can pump continuously for any length of time.

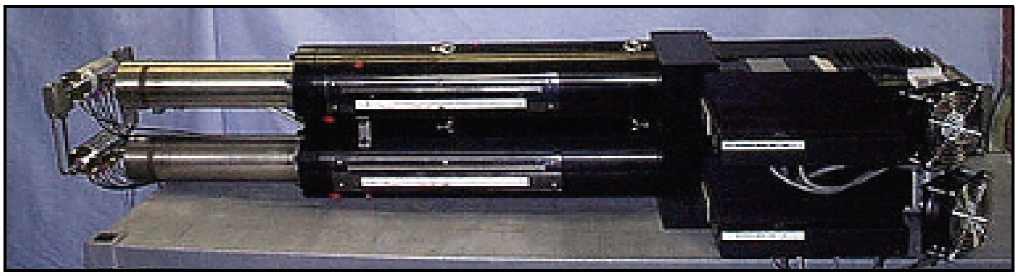


Figure 7-1.Q6000 Pump Cylinder Pair

The following options are available for the 6000 Series Pump System.

- Hastelloy wetted parts are available, and recommended, for users who pump highly corrosive fluids.
- High temperature parts permit users to heat the pump cylinder so that the fluid delivered is at reservoir temperatures. This option allows temperatures up to 160°C to be maintained within the pump.

7.2 Important Operating Notes

This section lists important operating notes for the Q6000 pump cylinders.

7.2.1 Operation at High Pressures

The Q6000 pump cylinder is designed for high pressure operation and uses a pressure transducer that corresponds to its maximum pressure rating (Refer to Table 7-1) If you plan to operate your 6000 Series Pump System at a pressure under 500 psi it will perform better with a pressure transducer with a lower pressure rating.

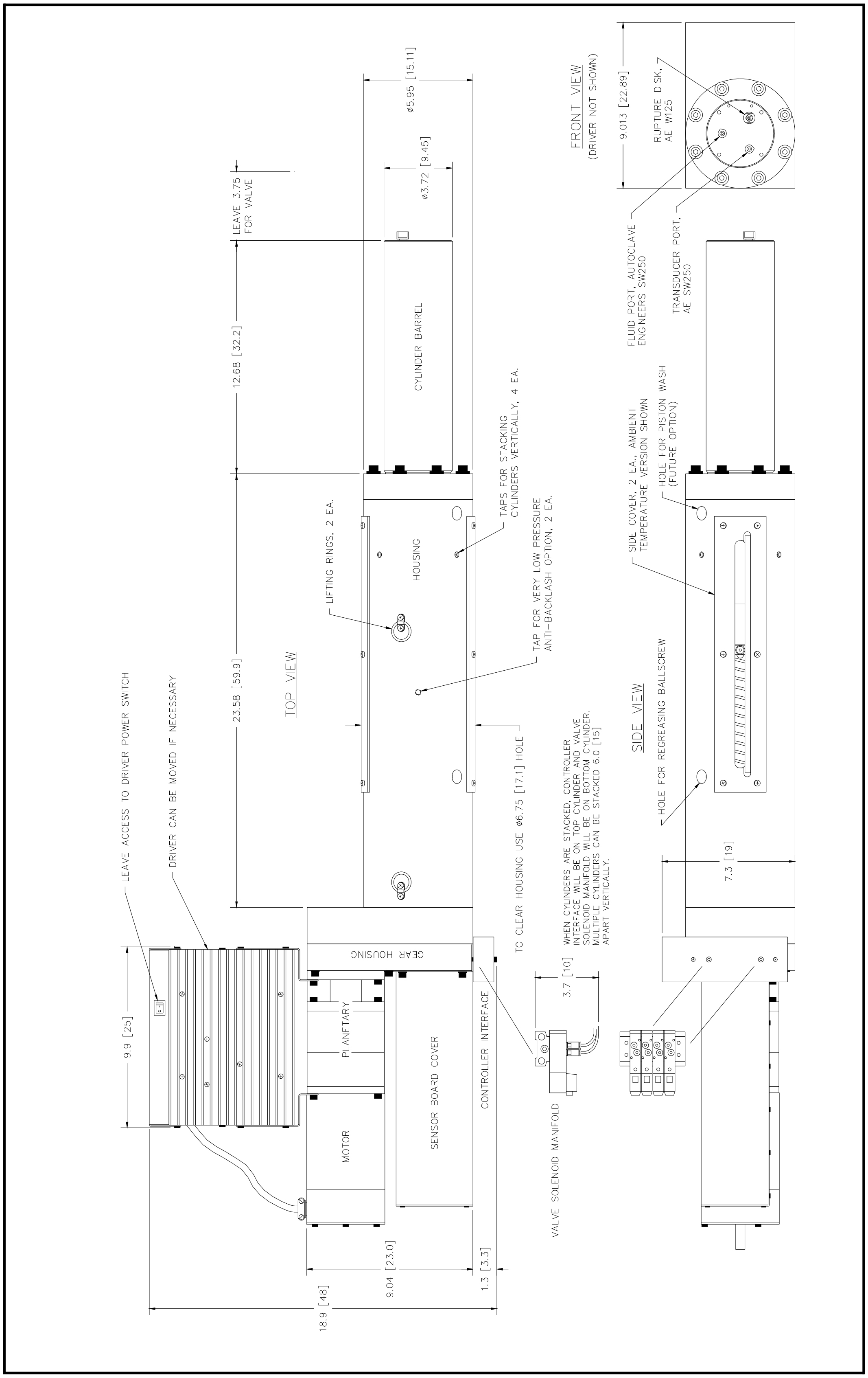


Figure 7-2 Q6000-AT Ambient Temperature Cylinder

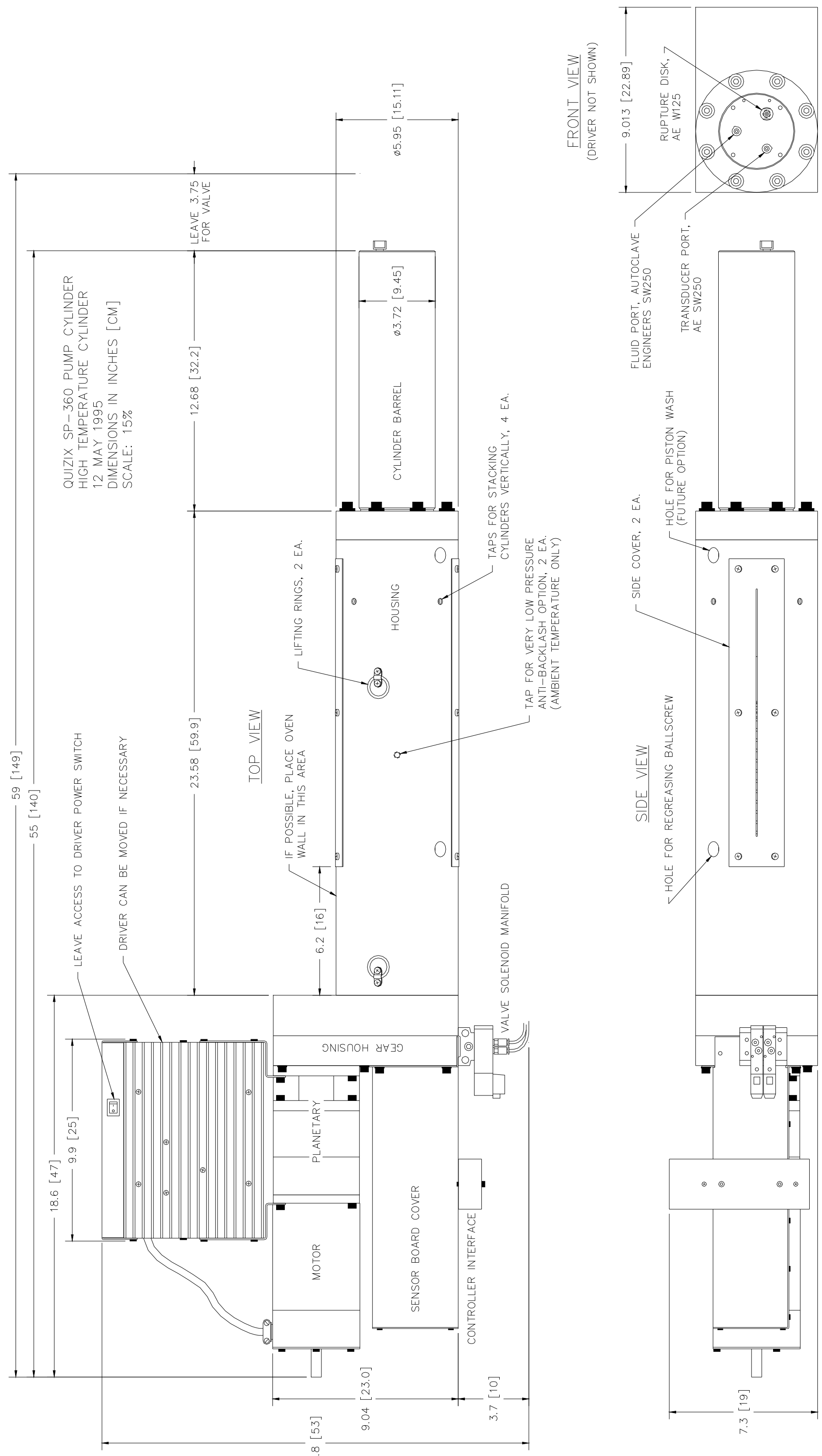


Figure 7-3 Q6000-HT High Temperature Cylinder

7.2.2 Orientation of the Pump Cylinder

The pump cylinder is designed to operate horizontally. It may malfunction if mounted in a vertical position.

7.3 Primary Mechanical Subcomponents of the Pump Cylinder

Starting at the motor end of the pump cylinder, the following subcomponents comprise the basic drive train of the pump.

7.3.1 Stepper Motor

The motor attached to the pump cylinder is a stepper motor, which rotates in the direction and at the speed dictated by the pump controller and the motor driver. A fan blows air over the motor to provide adequate cooling.

7.3.2 Planetary Drive and Helical Gears

The drive gear consists of a combination of a planetary drive and two helical gears. The gear reduction assembly uses a 37.8:1 ratio. The output of the drive gear assembly rotates once for every 37.8 revolutions of the stepper motor.

7.3.3 Ball Screw and Ball Nut

The ball screw and ball nut convert the rotary motion of the motor and drive gear assembly into linear motion. The ball screw moves back and forth as the ball nut rotates.The piston is screwed into the end of the ball screw. Rollers and side rails are used to counteract the torque.

7.3.4 Piston and Cylinder Barrel

The piston screws into the ball screw, so that it can be replaced easily. The piston moves into and out of the cylinder barrel following the motion of the ball screw. The piston is made of highly polished silicon carbide, which is extremely corrosion and scratch resistant

CAUTION
The piston is quite brittle, and therefore should never be dropped or handled roughly. Be extremely careful when handling the piston.

When the stepper motor rotates in a clockwise direction, the piston retracts and the cylinder barrel fills with fluid (assuming the fill valve is open and the deliver valve is closed). When the motor reverses direction, the piston extends and the pump delivers fluid (assuming the deliver valve is open and the fill valve is closed). Fluid is brought to pressure when both valves are closed and the piston extends to compress the fluid. When the piston is maintaining a specific pressure, the motion is referred to as "Servo" in PumpWorks.

In addition to the primary components described above, the following components are necessary to properly direct and contain the mechanical forces of the pump cylinder drive train.

7.3.5 Bearings

The pump cylinder contains both a radial bearing and a thrust bearing that secures the ball nut in place.

7.3.6 Side Rails and Cam Rollers

The side rails and cam rollers transfer the torque from the ball screw to two rollers (one on each side of the pump), then to the side rails which are directly under the side covers on each side of the pump cylinder. By transferring the torque, the ball screw will not spin and slide down the ball nut when fluid in the cylinder barrel is at high pressure.

Important
Never run the pump when the side covers are off. If the side covers are off when operating the pump, the side rails will fall off and damage the pump cylinder housing.

7.4 Pump Cylinder Barrel and Seal Assembly

7.4.1 Q6105 and Q6110 Models

The pump's cylinder barrel contains the fluid being pumped. There are two 1/4" Autoclave Engineers Speedbite® SW 250 fittings on the end of the cylinder barrel. Tubing that connects to the valves should be inserted into the upper speedbite fitting. This tubing serves as the inlet and outlet of the pump cylinder. Tubing from the pressure transducer should be connected to the lower fitting so that the pressure transducer can monitor pressure inside the cylinder barrel. See Figure 11-2 in Chapter 11.

7.4.2 Q6120 Model

The pump's cylinder barrel contains the fluid being pumped. There is a single fluid inlet/ outlet port. This port uses an F250C Autoclave high pressure fitting. The fluid tubing connects the safety rupture disk holder, pressure transducers and valves to the pump cylinder barrel by way of a cross tee.

7.4.3 Seal Assembly

The fluid is held in the cylinder barrel by a seal. The Q6000 uses a seal constructed of ultra high molecular weight polyethylene (UHMW), which is a soft plastic. High temperature versions of the pump contain seals made of Aflas® or sometimes PTFE, which is a type of Teflon®. Tests have shown that the seals used in the Quizix pump are leak–free, even after long periods of use.

CAUTION
The seals can be scratched and must be handled with extreme care during insertion.

The back–up ring serves two functions: it supports the seal and it guides the piston. Because the seal has no structural strength, it is supported by the back–up ring, which holds the seal in the seal cavity.

If the seal assembly is disassembled, be sure to keep each cylinder barrel, seal back–up ring, and piston from the same pump cylinder together as a group. For best operating results, the cylinder barrel, seal, back–up ring and piston should always be re–installed on the pump cylinder it was removed from.

For instructions on changing a seal, see Chapter 11.

7.5 Pump Cylinder Sensor Board

A sensor board is located on the back of the pump cylinder. This sensor board detects the position of the piston as it moves along its stroke by tracking the location of the ball screw to which the piston is attached. It does this by sensing four optic switches that are activated by a flag, which is attached to the ball screw. As the ball screw moves down the ball nut, each switch is activated in succession.

Ambient temperature versions of the pump cylinder have clear plastic side covers so that the position of the cam roller can be monitored visually. The side covers are marked with a scale of volume in milliliters, indicating the full range of the piston's motion. The cam roller can be used as an indicator of the piston's position.

High temperature versions of the pump cylinder have an aluminum cover with a slot cut into it for viewing the cam roller position.

7.6 Pump Cylinder Hastelloy Option for Corrosive Fluids

The standard pump cylinder is constructed of stainless steel (SS–316). If the Hastelloy option is specified, all metal pump cylinder parts that come in contact with the pumped fluid are constructed of Hastelloy C–276. The pressure transducer, however, is always 316 stainless steel. Hastelloy is highly corrosion-resistant and will extend the life of the pump substantially if you are pumping highly corrosive fluids.

7.7 Pump Cylinder High Temperature Option

Pump cylinder models Q6105 and Q6110 are available in a high temperature version that allows the pump cylinder to be heated to 160°C. The high temperature option is not available with the Q6120 model. The following lists the changes made to the high temperature version of the Q6000 pump cylinder.

- The side covers are made of aluminum, not plastic.
- The seal is made of Aflas, not UHMW polyethylene
- A different cam roller is used.
- Different greases are used.

The high temperature version of the Q6000 pump cylinder is designed so that the cylinder barrel and valves can be heated, thus eliminating termperature gradients in the fluid flow system. However, the stepper motor, motor driver, and sensor board cannot be heated. The pump cylinder must be placed in the oven so that the main pump housing extends through the oven wall, with the entire motor and fan cooling assembly residing outside of the oven. Generally, one hole must be cut in the oven wall for each pump cylinder.

7.8 Q6000 Pump Cylinder Motor Driver

The Q6000 pump cylinder motor driver is attached to the side of the pump. It has a sheet metal cover that protects the three connectors. Changing a motor driver is possible by removing the motor driver cover.

The Q6000 pump cylinder motor driver uses 120 volts AC ONLY. If your country uses 220 or 240 volts AC, a step–down transformer is provided to use with the motor driver for voltage conversion.

8 Valves and Plumbing

This chapter describes the following 6000 Series Pump System valve and plumbing components and options:

- Valves, Section 8.1
- Pilot Solenoids, Section 8.2
- Air Supply, Section 8.3
- Pressure Transducers, Section 8.4
- Fluid Plumbing, Section 8.5
- Safety Rupture Disks, Section 8.6
- High Temperature Option, Section 8.7

8.1 Valves

Chandler Engineering uses constant–volume, air–actuated valves manufactured by Vindum Engineering. 6000 Series Pump Systems use the following 3–way valves:

Valve	Pump	Pressure (psi)
CV-505	Q6105	5,000
CV-510	Q6110	10,000
CV-520	Q6120	20,000

Typically, there is one 3–way air-actuated valve for each pump cylinder in the system. Some 3–cylinder systems, however, may use only two valves. A high temperature option allows valves to be heated to 160°C.

The valves use a 3–way, T–formation design, so that each valve includes both a fill valve that controls the flow of fluid into the pump cylinder and a deliver valve that controls the flow of fluid out of the pump cylinder. Each valve has an inlet tube at one end, an outlet tube at the other end, and a tube that leads to the pump cylinder in the center. (See Figure 8-1)

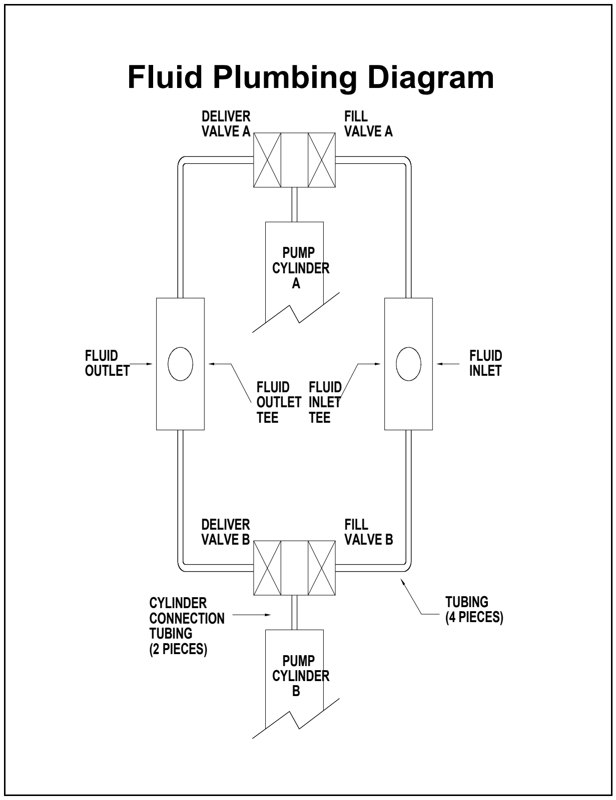


Figure 8-1

For fluid to flow into the pump cylinder, the fill valve must be open and the deliver valve must be closed. The fluid then flows into the valve, past the fill valve and out through the tube leading to the pump cylinder. For fluid to flow out of the pump cylinder, the fill valve must be closed and the deliver valve must be open. The fluid is then pumped out of the pump cylinder through the deliver valve and into the outlet receptacle.

Both the fill valve and the deliver valve are controlled by two air tubes from a pilot solenoid. Air flows through one of the tubes to open the valve and air flows through the other tube to close the valve.

When two Q6000 pump cylinders are operated in a paired mode, the valves open and close automatically so that one pump cylinder is filling while the other pump cylinder is delivering fluid. The Quizix pump system is designed so that the switchover process between pump cylinders is extremely precise and a constant rate or constant pressure is maintained at all times. During most pumping operations the valves operate automatically, opening and closing as necessary for the operating mode that is selected. However, PumpWorks allows the user to control the valves individually when desired. For further information about the features and specifications of the valves, refer to the Vindum Engineering manual.

8.2 Pilot Solenoids

The valves used in the Quizix pump system are air–actuated and require the use of electrically–operated pilot solenoids mounted onto a manifold. The pilot solenoids receive

electrical signals from the CN-6000 Pump Controller and convert these signals to air pulses that open and close the fluid path in the air–actuated, constant volume valves.

The pilot solenoids are connected to the pump controller with a valve cable. This cable branches out at the pilot solenoid end, providing one branch with a 2–pin connector for each pilot solenoid. The cable branches and pilot solenoids are numbered so that they can be connected properly, cable 1 connected to pilot solenoid 1, etc. When moving or re-configuring the pump system, the valve cable should be disconnected at the pump controller end, not the pilot solenoid end.

8.3 Air Supply

The valves used by the pump system are air–actuated. Air is taken into the system at the pilot solenoid manifold, then air lines connect the pilot solenoids to the valves. Air is exhausted from the system through two outlets labeled EA and EB in the pilot solenoid manifold.

The air fill valve at the bottom of the pilot solenoid manifold, labeled P, contains a 1/4–inch quick–disconnect fitting. The user inserts a section of 1/4" tubing into this fitting to connect the pump system to a pressurized air source that is regulated at 75 to120 psi. A standard laboratory air supply, with an air compressor, may be used. The air should be clean, dry, and oil–free.

The pilot solenoid manifold supplies air to all of the pilot solenoids. Each pilot solenoid actuates one fill or deliver valve through two air lines. Each Vindum CV valve has a fill valve and a deliver valve and thus requires a total of four air lines. The nylon tubing used as air lines to connect the pilot solenoids to the valves has a 1/8" outer diameter and is color–coded.

Because the air supply is used only when a pilot solenoid opens or closes a valve, **the system does not require a continuous air flow.** The amount of air used by the system to switch a valve is extremely small. However, because the pilot solenoids use a small quantity of air every time the valves are switched, operation from a gas bottle is not feasible because the bottle would be emptied too quickly.

IMPORTANT
Ensure that the air lines between the valves and the pilot solenoids are connected properly according to the color–coded markings. For example, the brown labeled lines should connect the valve which has a brown label to the pilot solenoid which has a brown label. If the valves or pilot solenoids are serviced, make sure that all of the color–codes match between the valves and pilot solenoids. For 4–cylinder pump systems with 8 pilot solenoids (16 air lines), each main color is used twice. The second set of pilot solenoids, number 5 through 8, contain a second black band. For example, there is a brown labeled air tube leading to the fill portion of pilot solenoid 1 for valve 1 and a black **and** brown–labeled air tube leading to the fill portion of pilot solenoid 5 for valve 3.

8.4 Pressure Transducers

Each pump cylinder is plumbed to a pressure transducer. The pressure transducer measures the fluid pressure inside the cylinder barrel and converts this pressure measurement to an electric signal. This electric signal is then sent to the CN-6000 Pump Controller through a transducer cable. The transducer cable has a 25–pin D–style connector at the pump controller end, then splits into one 6-pin circular connector for each pressure transducer.

The pressure transducers must be calibrated properly for the pump system to provide pulse–less flow. The pressure transducers can be calibrated by using the Pressure Calibration window in PumpWorks. This window allows the user to set an offset value and a gain value for each pressure transducer. See Chapter 11 in this manual and Chapter 9 in the PumpWorks User's Manual for more information on calibration.

8.5 Fluid Plumbing

The 6000 Series pump cylinders use 1/4" tubing for fluid flow plumbing and 1/8" tubing for the pressure transducer connections. This section describes the types of tubing that are necessary for system operation.

8.5.1 User–Supplied Tubing

For the fluid inlet, connect a section of 1/4" tubing from the fluid source to the tee labeled "fluid inlet". There is one fluid inlet tee for each pair of pump cylinders. A four–cylinder pump system has two fluid inlet tees.

For the fluid outlet, connect a section of 1/4" tubing from the fluid outlet tee to the user's experiment. There is one fluid outlet tee for each pair of pump cylinders. The fluid that flows through this tubing is at the user specified rate and/or pressure.

8.5.2 Plumbing Tubing

The following plumbing connections are provided in the 6000 Series Pump Systems. Refer to Figure 8-1 for a diagram of these plumbing connections.

- Inlet Tee to Valve Tubing
  Two sections of tubing are used to connect the inlet tee to the fill side of each valve.

- Outlet Tee to Valve Tubing
  Two sections of tubing are used to connect the outlet tee to the deliver side of each valve.

- Valve To Cylinder Barrel Tubing
  A piece of tubing connects the upper port on the cylinder barrel to the valve for the Q6105 and Q6110 pumps. A piece of tubing connects the port on the cylinder barrel to a cross and then to the valve for the Q6120 pump.

- Cylinder–to–Pressure Transducer Tubing
  One section of 1/8" tubing connects each pump cylinder to a pressure transducer. The pressure transducer tubing connects to the lower fitting on the end of the pump cylinder. The Q6120 uses a cross to connect the pressure transducer to the single port at the end of the cylinder barrel.

The plumbing in high temperature pump systems is very similar to the plumbing in ambient temperature systems. The major difference in high temperature pump systems is a longer length of tubing going back to the pressure transducer, which is mounted outside the oven.

IMPORTANT
Carefully check that all fittings are tightened. If fittings are not tight, leaks can occur. The pump system is checked thoroughly and is fluid–tight at the time it is shipped. However, Chandler Engineering recommends that you carefully check all the fittings prior to operation and when the pump system is altered. Most pump system leaks can be traced to fittings.

8.6 Safety Rupture Disks

Safety rupture disks are installed in each pump cylinder to prevent the system from exceeding a specified pressure. If the specified pressure is exceeded, the safety rupture disk ruptures and fluid is expelled from the safety rupture disk fluid exit port. The fluid exit port is fitted with an Autoclave 1/8" Speedbite fitting so that tubing can be attached to vent fluid to a container.

IMPORTANT
Ensure that tubing is installed from the safety rupture disk port to an appropriate receptacle to prevent fluid from spraying into the atmosphere if the safety rupture disk is activated. This is particularly important if you are using flammable or highly corrosive fluids.

See Chapter 5 for more information about the safety rupture disk. Also see Chapter 11 for safety rupture disk replacement.

8.7 High Temperature Option

The 6000 Series Pump System is available in a high temperature version that allows the pump cylinders and valves to be heated up to 160°C. The following changes are made to the plumbing in high temperature systems:

- Tubing used for the air connections between the pilot solenoids and valves are constructed of Teflon instead of nylon.

- The fittings on the valves, into which the air tubes are inserted, are Swage–type fittings instead of plastic quick–disconnect fittings. The Swage fittings have metal ferrules, which should be screwed tight when the air line is inserted.

When setting up a high temperature system, the following information regarding the pilot solenoids and pressure transducers should be considered.

8.7.1 Transducers

The standard pressure transducers operate at 70° C. They can be used at temperatures up to 80° C inside an oven without severely shortening their lifetime. However, for temperatures above 80° C, the pressure transducers must be mounted outside the oven. To facilitate their placement outside the oven, high temperature systems are shipped with a longer length of fluid tubing to connect the pressure transducer to the cylinder barrel.

8.7.2 Valves and Pilot Solenoids

The pilot solenoids cannot be placed in an oven. The pilot solenoids are placed just outside the oven so that the air tubes connecting the pilot solenoids and the valves are as short as possible. See the information prepared by Vindum Engineering about high temperature operation of the valves. The high temperature version of the valves can be heated to 160° C.

9 System Cables

The 6000 Series Pump System includes numerous cables that connect the components of the system. These cables are labeled so connecting them should be self–explanatory. All of the cables necessary to operate the 6000 Series Pump System are described in this chapter. Each cable is also described in the chapter(s) which explain the components the cables are connected to. This chapter includes:

- Motor Cable, Section 9.1
- Driver Cable, Section 9.2
- Sensor Cable, Section 9.3
- Transducer and Valve Cable, Section 9.4
- Data Link Cable, Section 9.5
- RS–232 Cable, Section 9.6
- AC Power Cables, Section 9.7
- User Interface Cable (Optional), Section 9.8
- SC-220 Driver Cable (Optional), Section9.9
- Front Panel Cable (Optional), Section9.10

9.1 Motor Cable

ALWAYS UNPLUG THE POWER CORD BEFORE UNPLUGGING THE MOTOR CABLE

The motor cable, which is part of the motor assembly, connects the pump cylinder's stepper motor to the motor driver. The motor cable is connected inside the motor on one end and inside the motor driver on the other end. If it is necessary to disconnect this cable, remove the motor driver cover and unplug the connection at the motor driver end.

9.2 Driver Cable

The driver cable, which has a 9–pin, D–style connector, is connected inside the motor driver and goes to the CN-6000 Pump Controller. There is one driver cable for each pump cylinder in the pump system. Each driver cable must be connected to the appropriate receptacle on the pump controller (driver A cable to driver A receptacle.)

9.3 Sensor Cable

The sensor cable connects the pump cylinder sensor board to the CN-6000 Pump Controller. There is one sensor cable for each pump cylinder in the pump system. The sensor cable is a flat ribbon cable with a 14–pin, ribbon–style connector with a key at both ends of the cable. The key has a ridge that fits one way only into a corresponding slot on the receptacle. Like

the driver cable, each sensor cable must be connected to the correct receptacle on the pump controller.

On the sensor board, there is also a 14–pin ribbon connector with a key. You should not disconnect the pump cylinder end of this cable. It is more convenient to disconnect the controller end when re-configuring or moving the pump system.

9.4 Transducer and Valve Cable

The transducer and valve cable connects the CN-6000 Pump Controller to the pressure transducers and the pilot solenoids for the valves. There will be one transducer and valve cable for each CN-6000 Pump Controller in your system. This round, shielded cable has a 25-pin, D-style connector at the pump controller end.

The transducer portion of this cable has two branches, one for each pressure transducer to be connected to the pump controller. Each branch has a 6-pin circular connector that should be connected to one end of the pressure transducer. The branch labeled "Transducer A" should be connected to Transducer A on pump cylinder 1A; the branch labeled "Transducer B" should be connected to Transducer B on pump cylinder 1B.

The pilot solenoid portion of this cable has four branches, one for each pilot solenoid. (There are two pilot solenoids for each Vindum Engineering CV valve). Each numbered branch has two wires, each with a 2-pin connector, that goes to a numbered pilot solenoid. If you reconfigure or move the pump system, this cable should be disconnected at the pump controller end and not at the pilot solenoid end.

Because this cable is designed for two pressure transducers and four pilot solenoids, if your pump system has an odd number of pump cylinders, there will be cable strands which are not used.

9.5 Data Link Cable

The Data Link Cable connects the CN-6000 Pump Controller with the serial expander/ isolator. There will be one data link cable for each CN-6000 Pump Controller in your pump system. They should be plugged into the ports of the serial expander/isolator in sequence: pump controller 1 connects with Port A, pump controller 2 connects with Port B, and so on.

Since the serial expander/isolator is typically mounted directly onto the pump controller, this cable is extremely short. If your system includes two pump controllers, there will be a longer data link cable to connect the second pump controller to Port B of the serial expander/isolator. The data link cable has RJ-22 connectors (phone-type connectors) at both ends.

9.6 RS–232 Cable

The RS–232 cable connects the serial expander/isolator to the system computer. This cable has a 9–pin, D–style connector at each end. The male end connects to the serial expander/ isolator receptacle, the female end connects to one of the serial ports on the computer. Most

users connect the RS–232 cable to serial port 1. You can choose another serial port to connect the RS–232 cable to, if you specify this in the system communications. Use the Configure Communications window in PumpWorks.

The standard RS-232 cable can be extended with any standard straight–through (one–to–one) 9–pin cable.

9.7 AC Power Cables

The CN-6000 Pump Controller has a power cord with a 3–prong connector that must be connected to AC power, preferably by way of an uninterruptable power supply. See Chapter 10 for more information. The power plug conforms to the standard outlet in the country to which the system is shipped. Standard IEC–320 appliance connectors are used at the pump controller end of these cables.

The motor driver has a power cord with a 3–prong connector that must be connected to **120 volts** AC power. It is not configured to the country in which the system is shipped. If your country has 220 or 240 volt power, a step–down transformer is provided to connect the motor driver to 220 or 240 power sources.

9.8 User Interface Cable (Optional)

The User Interface Cable allows the 6000 Series Pump System to connect to various external devices, which can be useful to the user for building a complete experimental system. Additional analog sensors, valves, digitally controlled devices and logic inputs, as well as power, are available on this 37-pin D-style connector. By connecting any such auxiliary valves, digital inputs, or analog inputs (such as additional temperature or pressure transducer readings) to the CN-6000, the user will have access to them from PumpWorks. The User Interface Connector also includes an emergency stop control signal for users who want to implement an emergency stop capability for their system.

Refer to Appendix C of the PumpWorks User's Manual for more information on the User Interface Cable, including the connector pin-outs. Refer to Chapter 9 of the PumpWorks User's Manual for more information on "Auxiliary Analog Input Signals" (Section 9.2), "Auxiliary Digital Input Signals" (Section 9.3), and "Auxiliary Valves" (Section 9.4) as they are viewed or controlled with PumpWorks.

If you have a recirculating system with the special software feature which allows the user to recirculate one or more fluids in a closed loop under pressure, a User Interface Cable will be included with your system. It is used to establish communications between the controllers in recirculating systems.

9.9 SC-220 Driver Cable (Optional)

The SC-220 Driver Cable connects the CN-6000 Pump Controller with the SC-220 Dual Cylinder Driver. This cable is used **only** if the CN-6000 is used with a 5000 Series Pump System which includes an SC-220 Dual Cylinder Driver. Such a situation occurs when a

CN-6000 Pump Controller is used to replace Quizix's earlier generation pump controller, the SC-2400 Pump Controller. The connector for this cable is a 36-pin, Centronix connector.

9.10 Front Panel Cable (Optional)

The optional Front Panel Cable connects the CN-6000 Pump Controller with the Front Control Panel, which may be used instead of PumpWorks to control the pump system. It is not available at this time.

10 System Power

This chapter describes the power requirements for the 6000 Series Pump System. It includes:

- Basic Power Requirements, Section 10.1
- Using Uninterruptable Power Supplies, Section 10.2

10.1 Basic Power Requirements

The 6000 Series Pump System has three components that must be connected to a power source: the CN-6000 Pump Controller, the motor driver, and the computer. Users conducting long–term experiments, in which the interruption of fluid flow would be detrimental to the experiment's results, should use an uninterruptable power supply with their system.

The CN-6000 Pump Controller is configured to the power requirements of the country to which it was shipped. If a computer was purchased from Chandler Engineering as part of your pump system, its power is also configured to the voltage and type of outlet used in the country it was shipped to.

The motor driver, which is mounted onto the pump cylinder, operates on AC current at **120 volts AC only** (for the 6000 Series Pump Systems). For countries that use 220 or 240 volts AC, a 120 volt power step–down transformer is provided. Plug the transformer to the power outlet, then plug the transformer into the motor driver's power cord.

WARNING
THE MOTOR DRIVERS FOR THE 6000 SERIES PUMPS ARE COMPATIBLE ONLY WITH 120 VOLTS AC. DO NOT USE THEM WITH 220 OR 240 VOLTS AC POWER. CHANDLER ENGINEERING PROVIDES A TRANSFORMER FOR CONVERTING 220 OR 240 VOLTS TO 120 VOLTS AC.

10.2 Using Uninterruptable Power Supplies

The 6000 Series Pump System can operate for extended periods of time--many months--without needing to be stopped. This capability is perfect for running long–term experiments such as steady–state rock property measurements. However, the pump system must have a source of AC power available at all times. Electronic equipment, such as computers and the CN-6000 Pump Controller, can be affected by brief power interruptions, power line surges and spikes. These power interruptions can be caused by switching large loads or lightning strikes.

To prevent these power line problems from causing improper operation of the pumping equipment, it is strongly recommended that users interested in obtaining data over extended periods of time use an uninterruptable power supply (UPS).

Chandler Engineering recommends a UPS that provides continuous on–line filtering and good AC line noise rejection, as well as power backup capabilities. Also, it is recommended that the time required for the unit to switch to back–up power be less than a few milliseconds.

The proper size for a UPS must be determined, based on the user's specific pump system and the type of power losses that are normally experienced. The first item that must be determined is the system power consumption. This can be determined using Table 10-1.

To keep the pump system operating, only the pump controller and motor driver need to be connected to the UPS supply. The computer can be turned off without affecting the operation of the pump system. However, if the computer is used to log data or perform timed operations, such as ramping of rates or pressures with the AutoOp feature, then the computer must also be connected to the UPS. The monitor does not have to be connected to the UPS, unless you want to view data or manually change parameters during a power outage.

Although many devices provide wattage ratings, most UPS systems are rated in volt–amps. Both ratings are listed for the components in Table 10-1.

Table 10-1. UPS Ratings

Component	Wattage	Volt–Amp
CN-6000 Pump Controller	5	5
Q6000 Series Cylinder (stopped)	150–250	200–300
(fully loaded)	250–500	300–600
Typical Windows 95–NT computer	60–400	80–500
Typical Windows 95–NT monitor	50–200	70–250

The length of time a power outage is likely to last should be considered when choosing a UPS. Enough battery capacity must be available, at the load required, to last for the length of the power outage. Most UPS systems list how long their battery can supply full and half–load power. This information can be used to determine the expected run–time with the load from the above calculation. Extra battery packs can be obtained for most UPS systems.

In case of an unusually long power outages, considerable power can be saved by turning off the monitor, or both the monitor and the computer. Further power savings can be obtained by stopping the motors, or running them at slower rates. Turning off equipment, of course, requires that the user be present.

11 System Maintenance

This chapter describes how to do preventive and corrective maintenance to the 6000 Series Pump System. This chapter includes:

- Special Tools and Spare Parts Kits, Section 11.1
- Maintaining the Cylinder Barrel, Section 11.2
- Maintaining the Cylinder Mechanics, Section 11.3
- Cooling Fan Maintenance, Section 11.4
- Servicing the Valves and Safety Rupture Disk, Section 11.5
- Calibrating the Pressure Transducers, Section 11.6

CAUTION
As a general safety precaution, always verify that there is no pressure in the pump before performing any service procedure. To accomplish this, open the valve (typically the fill valve), which vents the system to atmosphere.

11.1 Special Tools and Spare Parts Kits

Each 6000 Series Pump System is shipped with a Special Tools Kit and a Spare Parts Kit that you should use to service your system. A description of the Special Tools Kit for the all pump models is shown in Table 11-1 . A picture of the special tools for the Q6120 and Q6110 is shown in Figure 11-1. A picture of the Special Tools Kit for the Q6105 is shown in Figure 11-2. The Spare Parts Kit is shown in Table 11-2.

Table 11-1 Special Tools Kit

Item No.	Tool	Description
1.	piston insertion tool	This tool is used to remove and install the piston.
2.	22 mm open-end wrench	This wrench fits the flat area of the pressure transducer. It is used to hold the pressure transducer in place while tightening the fluid fittings
3.	adjustable face spanner wrench	This wrench is used to loosen and tighten the cylinder barrel and to remove and install the seal retaining nut.
4	Fluid plug and fluid nut	These are used when pressure testing for leaks.
5.	5/8" angled open-end wrench	This wrench is used to tighten the Speedbite® fittings and is especially useful for tightening the port(s) on the cylinder barrel.
6.	1/2" angled open-end wrench	This wrench is also used to tighten the Speedbite® fittings.

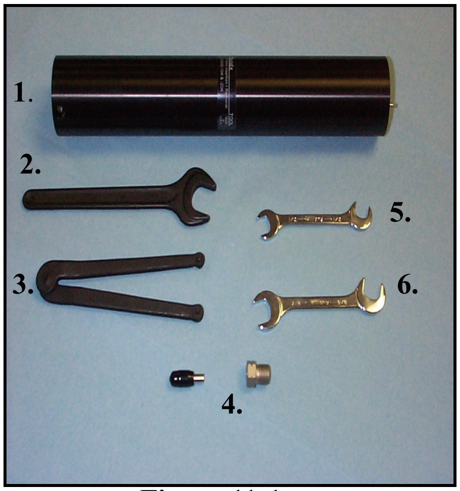


Figure 11-1
Special Tools Kit - Q6000 (10K and 20K)

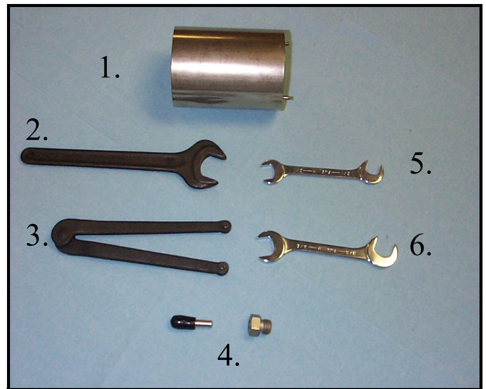


Figure 11-2
Special Tools Kit - Q6000 (5K)

Table 11-2 Spare Parts Kit	
Item No.	Description
1	Seals--Depending on the type of pump system that is ordered, the seals included are one of the following: • Cup–type ambient temperature seals made of ultra–high molecular weight polyethylene (white UHMW P–E) • T–type high temperature seals made of Aflas® (black) with accompanying Teflon® back–up ring.
2	Safety rupture disk. This is used in the safety rupture disk assembly. A specification tag is also included.

11.2 Maintaining the Cylinder Barrel

This section gives instructions for:

- Removing the Cylinder Barrel, Section 11.2.1
- How to Change the Seals, Section 11.2.2
- Removing the Piston (Optional), Section 11.2.3
- Replacing the Piston (Optional), Section 11.2.4
- Changing the Ambient Temperature Seals, Section 11.2.5
- Changing the High Temperature Seals, Section 11.2.6
- Reinstalling the Cylinder Barrel, Section 11.2.7

Recommended frequency for performing this maintenance on ambient temperature systems is every 12 months of regular use, or as required. For high temperature systems the recommended maintenance frequency is every 6 months of regular use, or as required.

For the purposes of this manual, the term “regular use” is defined as using the pump system 2 to 3 days per week, every week, at pressures greater than 35% of the rated cylinder pressure. If you are operating at lower pressures, very low rates, or infrequently, then the stated service intervals can be increased. Some conditions may require servicing the pump system more often. Unless stated otherwise, the procedures are the same for both the ambient and high temperature pump systems.

IMPORTANT
Excessive side loads on the piston during cylinder barrel installation or removal may break the piston.

11.2.1 Removing the Cylinder Barrel

1. Remove as much fluid from the pump cylinder as possible by opening the valves and extending the piston to the maximum extend position. By removing fluid from the pump cylinders, there will be very little fluid to spill out later.
2. Remove the fluid source and remove the tube that connects to the cylinder barrel fluid port. See Figure 11-4.
3. At this point it is important to retract the piston to the Max Retract position before proceeding. This protects the piston from accidental breakage and fills the cylinder with air.
4. Remove the tube that connects to the pressure transducer port. Some remaining fluid will flow out of the lower hole when this tube is removed.
5. Unscrew the cylinder barrel. If necessary, insert the spanner wrench in the holes on the front face of the cylinder barrel for more leverage. Sometimes the piston unscrews with the cylinder barrel. If this happens, be very careful not to allow the piston to drop on the floor. It might break.
6. As the cylinder barrel unscrews, be careful to always support it. If left unsupported, the weight of the cylinder barrel can break the piston. Be especially careful during the last thread when the cylinder barrel comes loose.
7. As the last thread releases, pull the cylinder barrel straight out and off of the piston and set it down.
8. Wipe up any spilled fluids on the inside of the pump housing.
9. Using the spanner wrench, unscrew the seal nut from the cylinder barrel.
10. Remove the seal and the back–up ring. For high temperature systems also remove the seal support ring. Clean the seal area with a clean lint-free cloth. Inspect the for any scratches on the metal where the seal makes contact. Scratches may cause fluid leaks.

11.2.2 How to Change the Seals

Seal life depends on the type of seal used, and the operating conditions of the pump (pressure, pump rate, and type of fluid that is pumped). The design of all Quizix pump cylinders makes changing seals a simple procedure.

- Typical seal life using water is approximately 8,000 hours.
- Fluids or slurries may require seal replacment sooner.
- High temperature seals usually operate between 2-5 temperature cycles.

NOTE: Your actual operating conditions may require an accelereated schedule for replacing the seals.

The cup–type seal used in Quizix pumps is shown in Figure 11-3. The seal is asymmetrical, with one side flat and one side having an open area around its circumference with a metal spring inside this opening. A cross–section of this type of seal resembles a cup or the letter U.

Cup–type seals are made from ultra–high molecular weight polyethylene (UHMW–PE), are used in ambient temperature applications and are normally white. Cup–type UHMW– PE seals have the longest life; one year minimum for normal service and two-plus years are possible. Pressure, flow rate, and fluid type do not significantly affect the life of these seals.

High temperature applications normally use a T–type seal made of Aflas. The high temperature seals have a shorter lifespan, which is strongly dependent on pressure and is related to the flow rate and type of fluid pumped. A normal effective life for these seals is six months of continuous use.

See Figure 11-3 for a cross–section diagram of the cup–type and the T–type seals.

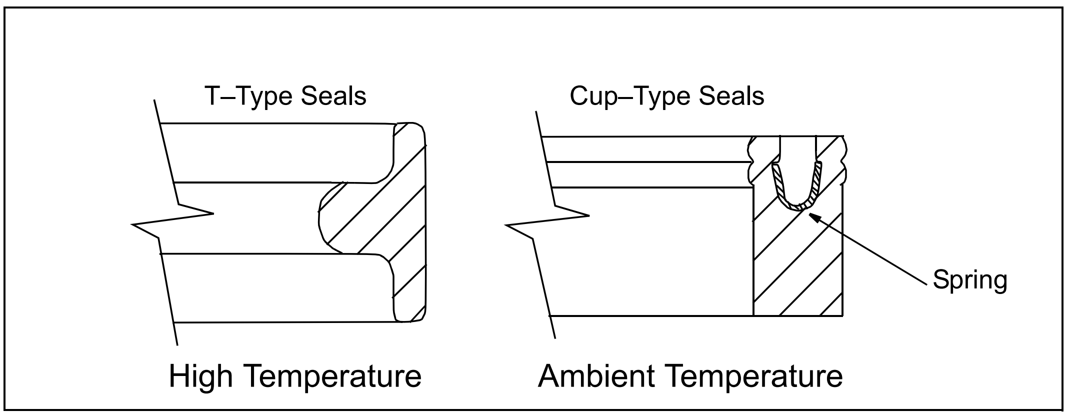


Figure 11-3 Seal Cross–Sections

IMPORTANT
For maximum performance from the seals, great care must be used when handling and inserting them. Seals are especially sensitive to damage by scratches that are not easily visible to the unaided eye. The seals can be easily scratched by any sharp object, including fingernails. The pump cylinder seal cavity can also be scratched easily. Do not use any sharp or hard objects to remove a seal or to clean a pump cylinder.

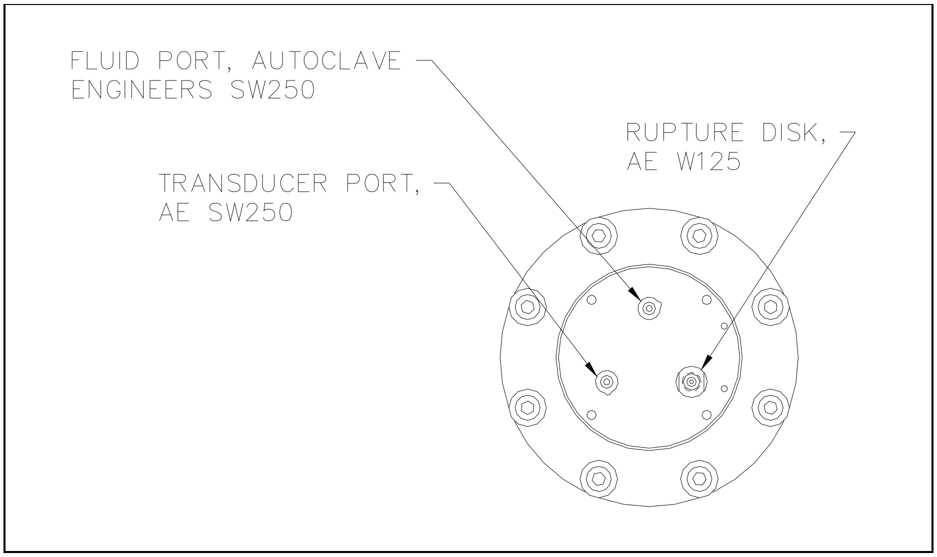


Figure 11-4 Front of Cylinder Barrel
(Q6105 and Q6110 models)

Note: The Q6120 only has a single fluid port fitting on the cylinder barrel.

11.2.3 Removing the Piston (Optional)

WARNING
The pistons are made from ceramic and are virtually unscratchable, but they are slightly brittle and can break. Keep side forces to a minimum and do not drop them.

1. To remove the piston, extend the piston to the Max Extend position and proceed with the following steps. Be careful not to bump the exposed piston from the side.
2. Slide the piston insertion tool, included with your system, onto the piston and turn it until the pins on the tool engage in the piston base.
3. Unscrew the piston. If necessary, insert the spanner wrench in the holes of the piston insertion tool for more leverage.
4. Inspect the piston carefully, looking for deposits or obvious damage, then wipe it clean with a clean, lint–free cloth.
5. If deposits are found, clean the piston with a solvent and a nylon scrub pad. DO NOT use any diamond or silicon ceramic based sandpapers or cleaning compounds on the piston.

11.2.4 Replacing the Piston (Optional)

1. To replace the piston, use the piston insertion tool and spanner wrench to screw it back into the cylinder barrel, then tighten it.

   Screw the piston into the cylinder barrel until it is hand tight. Use the piston insertion tool and spanner wrench to tighten the piston so that it is secure. If the piston is not screwed into the cylinder barrel tight enough, it will unscrew with the cylinder barrel the next time the cylinder barrel is unscrewed. Of course, you do not want to over-tighten the piston either, as this will make it difficult to remove next time.

   Important! Now retract the piston back to the Max Retract position. This provides the best protection for the piston so that it is not accidentally broken.

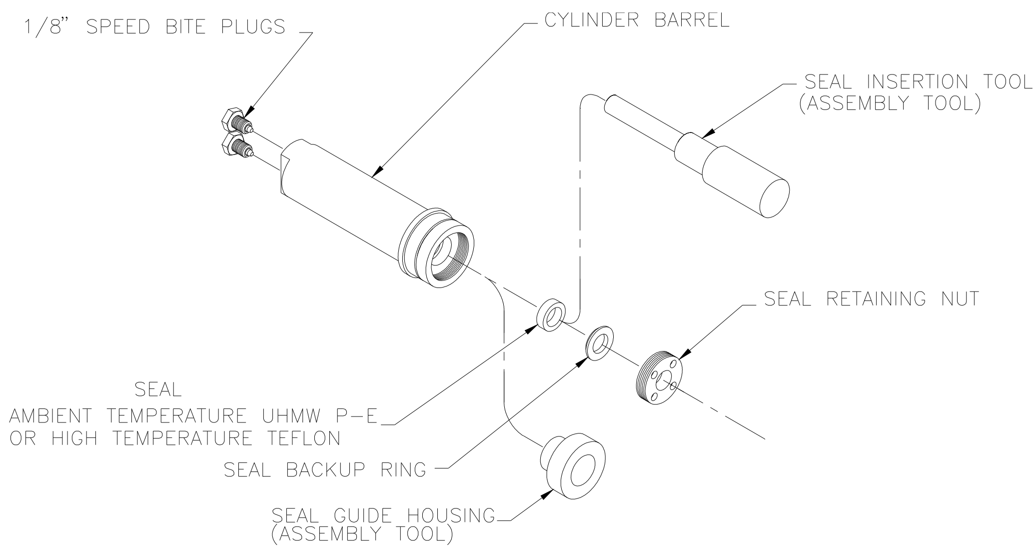


Figure 11-5 Ambient Temperature Seal Components

11.2.5 Changing the Ambient Temperature Seals

1. Manually place a new seal into the cylinder barrel and press it gently and evenly into place. The side with the spring is inserted first.

2. Put the back–up ring in next. You may insert either side in first.

3. Place the seal retaining nut over the back–up ring. Tighten using the spanner wrench.

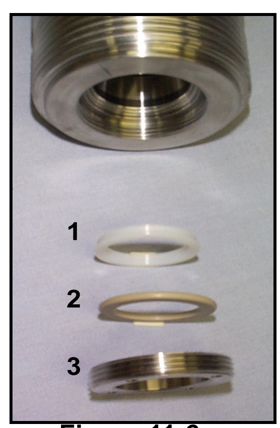


Figure 11-6

11.2.6 Changing the High Temperature Seals

For this section, we assume that the cylinder barrel is sitting vertically with the fluid port side on a table or flat surface and the seal area up.

1. Manually insert the tapered ring with the tapered side facing down into the cylinder barrel.

2. Insert the thick, rounded, PEEK ring with the flat side resting on the tapered ring inserted in step 1. This leaves the rounded side up to fit against the curve of the seal.

3. Insert either side of the T–seal over the PEEK ring.

4. Insert the thin, rounded, Teflon® ring with the rounded side facing down towards the curved surface of the T-seal.

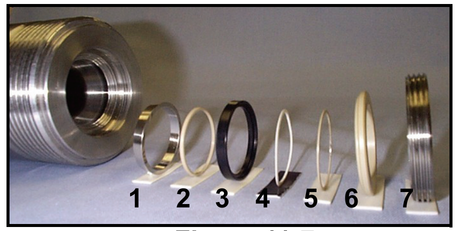


Figure 11-7

5. Insert the thin, flat, PEEK ring with either side facing up on top of the Teflon ring.

6. Insert the large, back–up ring with the flange or stepped side facing down on top of the PEEK ring.

7. Screw in the seal nut and tighten using a spanner wrench.

11.2.7 Reinstalling the Cylinder Barrel

1. Carefully pick up the cylinder barrel and align with the threads on the pump housing. Push the cylinder barrel onto the piston and screw the cylinder barrel back into the pump. Do not allow the weight of the cylinder barrel to press down on the piston or the piston will break.
2. Screw the cylinder barrel down until it is seated against the pump housing. When properly seated, the fluid inlet port should be at the top of the cylinder barrel.
3. Replace the tubing to the fluid valve and the pressure transducer.
4. Test the pump for proper operation and seal performance (no leaks). Fill the pump system with fluid, pressurize and check for leaks.

11.3 Maintaining the Cylinder Mechanics

This section describes maintenance of the moving parts of the Q6000 pump cylinder. It includes the following:

- Replacing the Cam Rollers, Section 11.3.1
- Re-Greasing the Ball Screw, Section 11.3.2
- Re–Greasing the Planetary Gear, Section 11.3.3
- Re–Greasing the Helical Gears, Section 11.3.4

11.3.1 Replacing the Cam Rollers

The recommended frequency for replacing the ambient temperature system cam rollers is every 2 years of regular use, or as required. The recommended frequency for replacing the high temperature system cam rollers is every 1 year of regular use, or as required.

A cam roller is located on each side of the pump cylinder. There are different cam rollers on the ambient temperature pump systems than there are on the high temperature pump systems. These components, while simple, perform an important function in the pump system. Their internal lubrication can dry out over time, especially on the high temperature pumps. The following procedure explains how to confirm the cam rollers are working properly and are lubricated correctly, and how to replace them if necessary.

1. Remove the cylinder housing side covers. To do this, remove the six (6) screws that attach the side covers to the cylinder housing. See Figure 11-8 and Figure 11-9.
2. Grasp the cam roller with two fingers and make sure it feels smooth and non–binding when it is rotated.
3. Look at the steel side rails on which the cam rollers roll. Do they have any marks on them other than a straight wear path parallel to the sides of the rails? If so, the cam rollers should be replaced.
4. Place a 1/8" Allen wrench into the center of the cam roller and unscrew the cam roller from the flexure.
5. Replace the cam roller, if necessary. Make sure you replace the ambient temperature cam roller with another ambient temperature cam roller, and the high temperature cam roller with another high temperature cam roller. Using a 1/8" Allen wrench screw the cam roller into the flexure. Always replace cam rollers in pairs, never replace a single cam roller.

   The recommended cam roller to use for ambient temperature systems is the McGill Model CCFH 1/2 N SB. For high temperature systems, the recommended cam roller to use is the McGill CCFH 1/2 NB–W1K.

6. Repeat Steps 1 through 5 for the left side cam roller.

11.3.2 Re-Greasing the Ball Screw

The recommended frequency for re-greasing the ball screws in ambient temperature pump systems is every 2 years of regular use, or as required. The recommended frequency for re-greasing the ball screws in high temperature pump systems is every 1 year of regular use, or as required.

On each side of the pump cylinder is a side cover. The ambient temperature pump's side covers are clear, acrylic panels through which the ball screw can be viewed. The high temperature pump's side covers are black anodized aluminum with a slot cut into them for viewing. Refer to Figure 11-8 for a view of the ambient temperature pump cylinder and Figure 11-9 for a view of the high temperature pump cylinder.

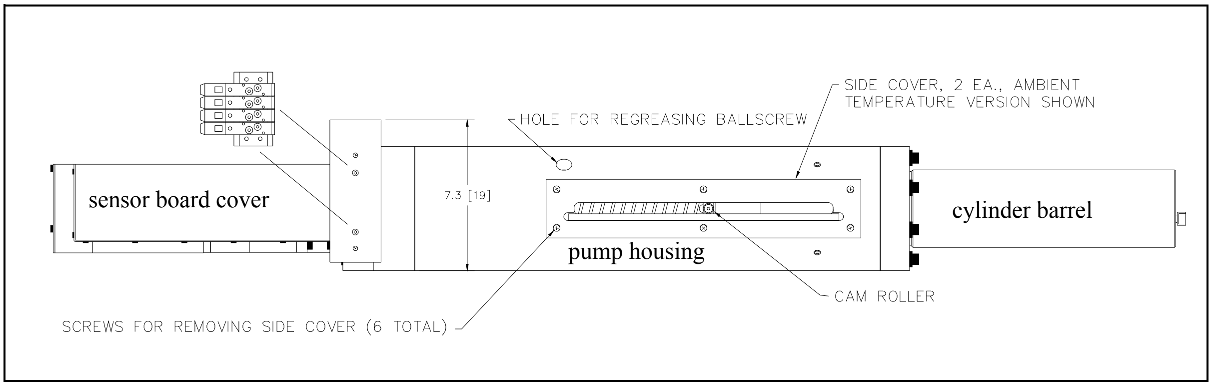


Figure 11-8 Pump Cylinder Side View, Ambient Temperature

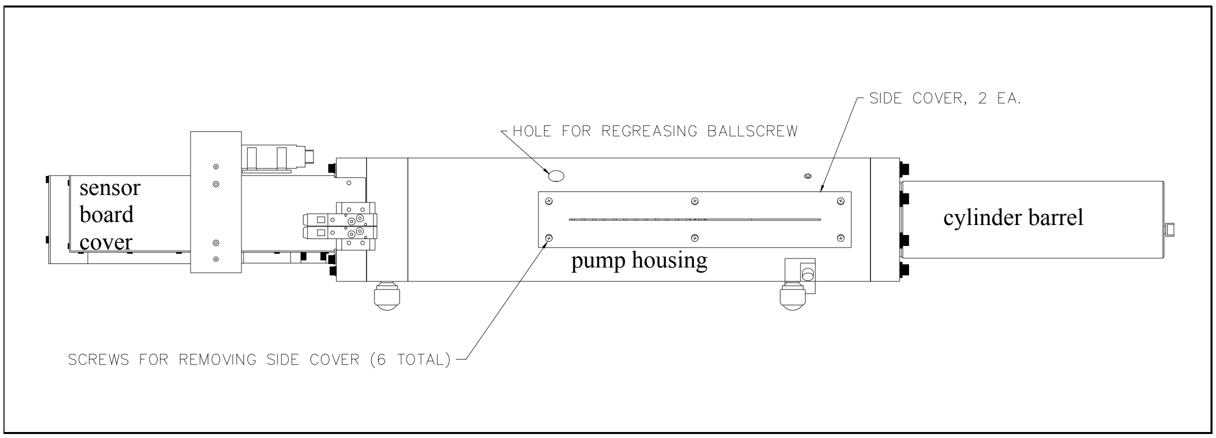


Figure 11-9 Pump Cylinder Side View, High Temperature

To grease to the ball screw, use the following procedure:

1. Extend the pump to the Max Extend position.
2. Slowly retract the pump cylinder until the grease fitting is visible.
3. Using a grease gun, apply grease into the grease fitting through the hole for regreasing the ball screw. Use Aerospace Lubricants Tribolube–37 RPC/MS grease. This grease is available from Chandler Engineering.

The system is now ready for normal use.

11.3.3 Re–Greasing the Planetary Gear

1. Using a 3/16" Allen wrench, remove four (4) screws to remove the motor assembly and expose the planetary gear. See Figure 11-10.
2. Using a grease gun, grease the planetary gear. Use Mobilith SHC–220 grease.

3. Using a 3/16" Allen wrench, install the four (4) screws to reinstall the motor assembly.

11.3.4 Re–Greasing the Helical Gears

1. Using a 5 mm Allen wrench, remove the six (6) screws on the gear housing to expose the helical gear. See Figure 11-10.
2. Apply grease using a spatula or by hand. Use High–temp Moly Lith No. 2 grease.
3. Using a 5 mm Allen wrench, replace the six (6) screws to reinstall the gear housing.

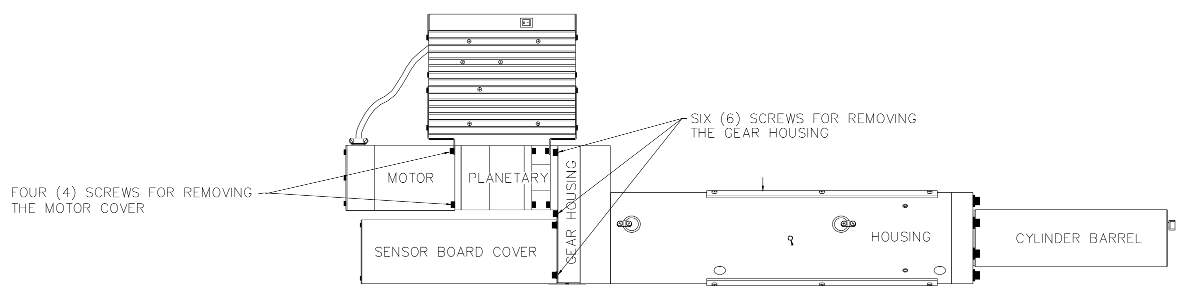


Figure 11-10 Re–Greasing the Pump Gears

11.4 Cooling Fan Maintenance

The cooling fan is mounted to the motor. If the fan stops operating, or if it is operating erratically in any way, contact Chandler Engineering for motor driver fan replacement.

11.5 Servicing the Valves and Safety Rupture Disk

11.5.1 Servicing the System Valves

For complete information on servicing the CV–505, CV-510 and CV-520 valves on the 6000 Series Pump System, refer to the "High Pressure Valves User's Manual" from Vindum Engineering.

11.5.2 Replacing the Safety Rupture Disk

The recommended frequency for replacing the safety rupture disk is every 2 years of regular use.

Safety rupture disks are installed to prevent the system from exceeding a specified pressure. The safety rupture disk is activated if there is a pressure transducer failure that cannot be detected by the normal safety systems, or in the extremely unlikely event of a hardware or software failure in which the system does not respond to normal controls. In such a case, this disk protects the Quizix pump from damage.

Table 11-3 Safety Rupture Disk's Activation Pressure

Model	Maximum Pressure of Pump	Safety Rupture Disk's Activation Pressure
Q6105	5,000 psi	6,500 psi
Q6110	10,000 psi	12,750 psi
Q6120	20,000 psi	25,000 psi

The safety rupture disk included in Quizix pump systems is a *one–time only* item that must be replaced after it has been activated. It is not a pressure relief valve and cannot be tested. If the system pressure is brought to a level that activates the disk--it breaks, and must be replaced. Refer to Chapter 5 for more information about safety rupture disks and a table of the pressure ratings to be used.

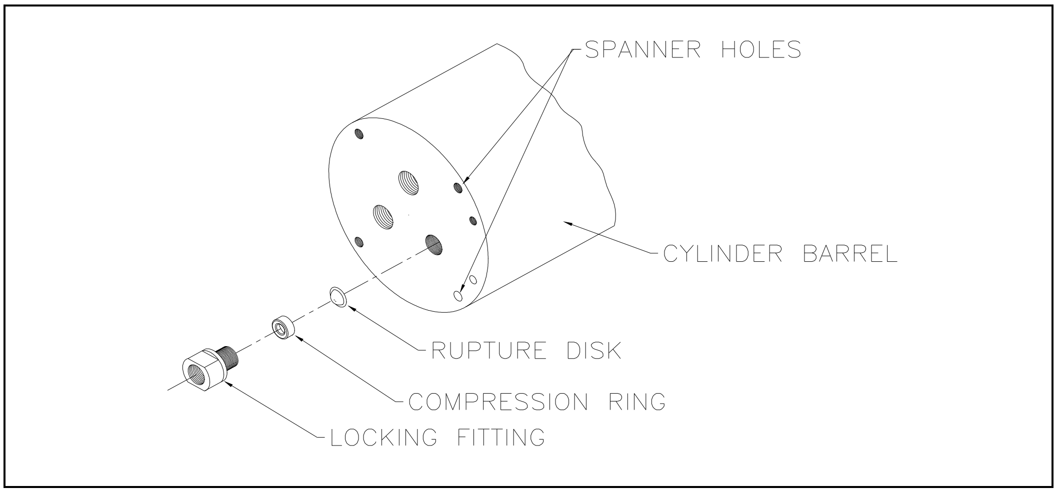


Figure 11-11 Safety Rupture Disk

11.5.3 Q6105 and Q6110 Models

To replace a safety rupture disk for the Q6105 and Q6110, use the following procedure. See Figure 11-11.

1. Insert a spanner wrench into the spanner holes, or use a vise to hold the cylinder barrel. Unscrew and remove the locking fitting.
2. Remove the locking fitting, compression ring, and old safety rupture disk.

3. Carefully and completely clean out the seating area for the safety rupture disk. Also clean the new safety rupture disk and compression ring so that they are free of any dirt or contaminating particles.
4. Insert the new safety rupture disk into the pump cylinder, making sure the bulge in the disk is outwards (convex).

   It is very difficult to see if the disk is convex or concave by looking at it. It is better to take a smooth rod and feel if the disk is in place so that the center is higher than the edges.
5. Place the compression ring on top of the safety rupture disk, then screw in the locking fitting. The compression ring is symmetrical, so it can be installed with either side down.
6. Screw the locking fitting finger tight. Next, use a torque wrench to tighten the locking fitting to the torque specified on the metal tag attached to the safety rupture disk. The torque depends on the pressure rating of the safety rupture disk.

NOTE: The safety rupture disk's type, model number, and torque specification are printed on the tag that which is attached to it. If the safety rupture disk in your system does not contain a torque specification on its tag, use Table 11-4.

Table 11-4 Safety Rupture Disk's Torque Ratings

Safety Rupture Disk Pressure, kPa (psi)	Torque, Newton–Meters (ft– lbs)
3,000	38 (28)
6,500	45 (33)
12,500	57 (42)
25,000	163 (120)

Additional safety rupture disks may be obtained from Chandler Engineering.

11.6 Calibrating the Pressure Transducers

The pressure transducers on the 6000 Series Pump System need to be recalibrated periodically. During normal use they should be recalibrated every 12 months. If usage is heavy, or if the pump has been subjected to unusual circumstances such as pressures above its rated pressure range, then recalibration should be performed. Also, pressure transducers should be recalibrated after being taken apart and put back together.

Calibration keeps the two individual pressure transducers (on two pump cylinders used as a pair) reading the correct pressure. The CN-6000 Pump Controller uses these pressures to match the standby pump cylinder's pressure to the delivery pump cylinder's pressure to eliminate pressure variations at switchover. If the two pressure transducers are not matched to each other, than the pressure in one pump cylinder will not be the same as the pressure in the other pump cylinder, even though the readings on the display will match. The easiest

way to check if the pump cylinders are matched is to use one pump cylinder to pressurize both pressure transducers (connect pump cylinders together) and record the pressure of both pressure transducers over the pressure range of interest.

11.6.1 What is a Pressure Transducer?

A pressure transducer is a device that converts a pressure to an electrical signal proportional to that pressure. In the 6000 Series Pump Controller, the signal generated by the pressure transducer is sent directly to an A/D (analog-to-digital) converter which converts the analog electrical signal of the amplifier to a 20-bit digital signal that is displayed on the computer.

Each individual pressure transducer will have slight variations in zero pressure output voltage (zero offset) and its output voltage at full pressure (gain). In the 6000 Series Pump System these variations are compensated for in the controller software. The process of adjusting the offset and gain compensation values is called calibration.

11.6.2 Methods of Calibrating the Pump System

There are two basic methods of pressure calibration for all Quizix Pump Systems. The first method is to attach a secondary calibrated gauge, such as a quartz transducer, to the system. With this method, the pressure for the calibration procedure will be generated by the Quizix pump. Then the pressure read by the Quizix system is adjusted until the system's transducer readings match the reading by the calibrated gauge (CG).

The second method is to use an external pressure source, such as a "dead-weight tester." With this method the user connects the external calibrated pressure source (PS) to the pump system. The pressure is then read by the pump system and adjusted until it matches the pressure being output by the pressure source.

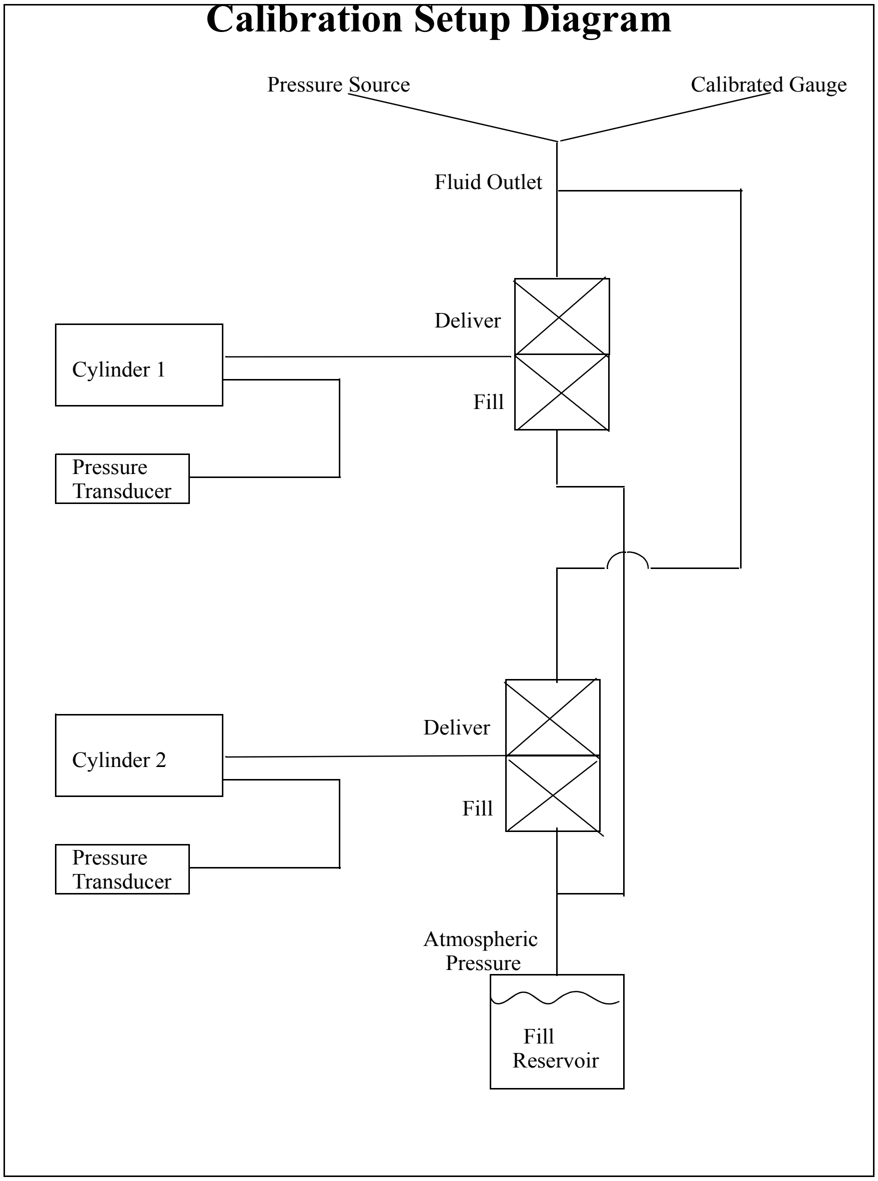


Figure 11-12

11.6.2.1 Calibrated Gauge

1. As shown in the Calibration Setup Diagram in Figure 11-8, connect a calibrated gauge (CG) to the fluid outlet of your Quizix Pump System. Be sure your fill valves are connected to a fill reservoir at atmospheric ("zero gauge") pressure.

2. Set the system to "zero gauge pressure" as follows: for the cylinder(s) being calibrated, open the fill valve(s) so the cylinder pressure is at atmospheric or "zero" pressure. The deliver valve(s) can also be opened, if desired.

3. Adjust the offset. Go to PumpWorks main window. From the menu bar select Other | Software Pressure Transducer Calibration. In the Software Pressure Transducer Calibration window, select “Current Offset”. The easiest way to adjust the offset is to select “Auto Zeroing”. Doing this will result in the computer calculating the necessary offset to have the display read zero pressure. The range of zero offset is limited so that a malfunctioning transducer or a transducer with significant pressure accidentally left on it, will not be able to be zeroed.

   Alternatively, the user can compute the desired offset and enter this value into the appropriate box. With this option the user can have the display show a value other than zero pressure on the display when zero pressure is present. This can be used if absolute pressure readings are desired.

4. Set the pressure to 90% of the system’s maximum rated pressure.

5. Set the safety pressure to 95% of the system’s maximum rated pressure.

NOTE: If your system is typically operated at significantly less than the pump’s maximum rating (for example, typical usage at 100 PSI for a 5,000 PSI pump), then the pressure in this step may be set at the system’s typical operating pressure to obtain a more accurate calibration.

6. For the pump cylinder(s) being calibrated, open the deliver valve(s) and close the fill valve(s).

7. Use PumpWorks to set the pump cylinder you are calibrating to extend in Constant Rate Independent Mode (#1), at 1 ml/minute. Start the pump cylinder and monitor the pressure with the calibrated gauge.

8. Stop the pump when pressure reaches 90% of the system’s maximum pressure.

IMPORTANT
When you raise the system’s pressure, the temperature of the pump’s internal fluid will temporarily rise. As this fluid cools, the system pressure will drop. In this situation it is best to wait five minutes after reaching your high pressure before proceeding, so that the pressure is not changing while you are trying to calibrate.

9. Adjust the gain. Go to PumpWorks main window. From the menu bar select Other | Software Pressure Transducer Calibration. In the Software Pressure Transducer Calibration window, select “Current Gain”. The easiest way to adjust the gain of a pressure transducer is to enter the current pressure value into the Enter Known Pressure box. When this is done, PumpWorks calculates the necessary gain and adjusts the pressure reading to display this value automatically. Please remember to always adjust the offset prior to adjusting the gain.

The user may also calculate the desired gain by hand and then enter the desired value into the software. The range of gains is limited to prevent faulty and malfunctioning transducers from being calibrated and giving the illusion of working. For more information on calculating offsets and gains, see Section 9.1.3, "How to Calculate an Offset and Gain", in the PumpWorks User's Manual.

11.6.2.2 Calibrated Pressure Source

1. As shown in the Calibration Setup Diagram in Figure 11-8, connect a calibrated pressure source (PS) to the fluid outlet of your Quizix Pump System. Be sure your fill valves are connected to a fill reservoir at atmospheric (“zero gauge”) pressure.

2. Set the system to “zero gauge pressure” as follows: for the cylinder(s) being calibrated, open the fill valve(s) so the cylinder pressure is at atmospheric or “zero” pressure. The deliver valve(s) can also be opened, if desired.

3. Adjust the offset. Go to PumpWorks main window. From the menu bar select Other | Software Pressure Transducer Calibration. In the Software Pressure Transducer Calibration window, select “Current Offset”. The easiest way to adjust the offset is to select “Auto Zeroing”. Doing this will result in the computer calculating the necessary offset to have the display read zero pressure. The range of zero offset is limited so that a malfunctioning transducer or a transducer with significant pressure accidentally left on it, will not be able to be zeroed.

   Alternatively, the user can compute the desired offset and enter this value into the appropriate box. With this option the user can have the display show a value other than zero pressure on the display when zero pressure is present. This can be used if absolute pressure readings are desired.

4. Set the pressure to 90% of the system's maximum rated pressure.

5. Set the safety pressure to 95% of the system's maximum rated pressure.

NOTE: If your system is typically operated at significantly less than the pump's maximum rating (for example, typical usage at 100 PSI for a 5,000 PSI pump), then the pressure in this step may be set at the system's typical operating pressure to obtain a more accurate calibration.

6. For the pump cylinder(s) being calibrated, open the deliver valve(s) and close the fill valve(s).

7. Set the pressure source to bring the pressure up to the desired level.

8. Adjust the gain. Go to PumpWorks main window. From the menu bar select Other | Software Pressure Transducer Calibration. In the Software Pressure Transducer Calibration window, select “Current Gain”. The easiest way to adjust the gain of a pressure transducer is to enter the current pressure value into the Enter Known Pressure box. When this is done PumpWorks calculates the necessary gain and adjusts the pressure

reading to display this value automatically. Please remember to always adjust the offset prior to adjusting the gain.

The user may also calculate the desired gain by hand and then enter the desired value into the software. The range of gains is limited to prevent faulty and malfunctioning transducers from being calibrated and giving the illusion of working. For more information on calculating offsets and gains, see section 9.1.3, "How to Calculate an Offset and Gain" in the PumpWorks User's Manual.

This page intentionally left blank.

12 TROUBLESHOOTING

This chapter will help the user solve problems they might encounter when operating their pump. It is divided into the following areas.

- Troubleshooting Basics, Section 12.1
- PumpWorks Error Messages, Section 12.2
- CN-6000 Two Digit Display Error Messages, Section 12.3
- Air Supply Problems, Section 12.4
- Fan Does Not Run, Section 12.5
- Fluid Leaks, Section 12.6
- No Fluid Is Being Delivered, Section 12.7
- Piston Motion Errors, Section 12.8
- Pressure Problems, Section 12.9
- Valve Problems, Section 12.10
- Software Updates, Section 12.11

12.1 Troubleshooting Basics

In 6000 Series Pump Systems with two or more pump cylinders, the pump cylinders can be compared to each other in order to isolate the cause of some problems. Also, the removable parts of the pumps are interchangeable and can also be used to help isolate the cause of a problem. The removable parts include the cylinder barrels, seals, pistons, transducers and valves. Note that the transducers can be interchanged, but will require recalibration if this is done. An example is pump cylinder A is leaking, and continues to leak after replacing the seal. The user needs to determine if the problem is the cylinder barrel or the piston. To find out, a user could exchange the cylinder barrels between pump cylinders A and B. If the leak moved from pump cylinder A to pump cylinder B, then we know the problem is either the cylinder barrel or the seal that is inside of the cylinder barrel. If, however, the leak continued coming from pump cylinder A, then we know there is a problem with the piston, such as a scratch or hard deposit.

When trying to figure out the cause of a problem within the 6000 Series Pump System, there are several PumpWorks features that could give the user more information. They are:

- **Current System Status Window**
  The Current System Status window, located on the Error/Log menu, shows the current state of all pumps being controlled by PumpWorks. Items in green indicate that no errors are present and items in red indicate that an error is present. Errors that do not apply are grayed, as well as pumps that are not installed. For ease of viewing, pumps 1 through 4 are shown in one window, while pumps 5 through 8 are displayed on a separate window.

- **Error Log**
  PumpWorks maintains a log of all errors. Each error entry consists of the date and time the error occurred, as well as a description of the error. The most recent errors are displayed in the Current Errors Log. The Previous Errors Log maintains a list of all errors, present and past, that have been detected by PumpWorks up to a maximum file size set by the user.

- **Physical Piston Position Indicators**
  Every Q6000 Pump Cylinder has side covers which allow the user to view the piston's position. The side covers on ambient temperature cylinders are clear acrylic panels through which the ball screw can be viewed. The side covers on high temperature cylinders are black anodized aluminum with a slot cut into them for viewing. The user can watch the piston move all along its stroke, from its Max Retract position to Max Extend position (or vice versa).

- **Cylinder Switch Status Window**
  The Cylinder Switch Status is located on PumpWorks Error/Log Menu. This window displays the current readings obtained from the motion sensor board of the pump cylinders. The sensor board indicates the position of the piston. The Cylinder Switch Status window is useful if there is an error message related to the piston position control switches. For a complete description of this feature, see Section 10.5 of the PumpWorks User's Manual.

- **Error State Capture Mode**
  In Error State Capture Mode, the user can view an instant replay of the conditions of the pump before and after an error occurred. In the same way that a video camera can capture an event, PumpWorks can capture an error. If an error occurs, PumpWorks records the error and all pump operating information. The captured information is saved to the computer's hard drive from 180 seconds before until 30 seconds after the error occurred. This data can then be viewed by switching to the Error State Capture Mode, located on the Error/Log menu.

  Once in Error State Capture Mode, the user double clicks on an error in the Previous Errors Log. "Control Error State Capture" then becomes an option on the Error/Log menu. Control Error State Capture is used to scroll through the error transactions so the user can view the flow rates, pressures and volumes the pump was reporting before and after the error occurred.

  The Error State Capture Mode data is stored in two files, Pumpworks.est and Quizix.erl. These two files, plus the Pumpworks.ini file, contain the complete error information. By viewing the data in the Error State Capture Mode, the user can usually figure out what has gone wrong. In the event of a problem that the user cannot figure out, these three files can be sent to Chandler Engineering and used to help figure out what caused the error.

  Please refer to the PumpWorks User's Manual for more information about Error State Capture Mode.

12.2 PumpWorks Error Messages

When PumpWorks recognizes that an error has occurred in the pump system, an error message is generated. “Errors Present” will appear against a red background on the status bar. The Current Error Log, which is located on the Error/Log menu, will list the error date, what time it was when the error occurred and give a description of the error. The error will also be recorded in the Previous Error Log, where a list is maintained of all errors, present and past, that have been detected by PumpWorks (up to a maximum file size set by the user). Some errors are “immediate errors” and some are “logged errors”, which we will discuss in the following sections.

12.2.1 Immediate Errors

An Immediate Error is generated in response to a command sent by the user. This is generally the result of a user asking the pump to do something that is not permitted. An example is trying to open or close a valve, or change the operating mode of a pump cylinder that is currently running. A dialog box immediately appears on the screen with an error message. The text in the dialog box clearly explains what prevents the requested action from being executed.

An immediate error is NOT logged to the Current Error Log or the Previous Error Log. The status bar of the PumpWorks main window reads “No Errors” and the motion status display does not show an error status for that pump cylinder.

12.2.2 Logged Errors

A logged error is entered into the Current Error Log and Previous Error Log, but no dialog box appears on the screen. The status bar of the PumpWorks main window displays Error Present or Check Error Log. Most logged error messages are very easy to understand and the user is able to correct the problem quickly. An example of a logged error is “Error Over Pressure on Cylinder 1A” This means that the safety pressure in pump cylinder 1A, set by the user, was exceeded by the pump cylinder and caused a digital overpressure error. This error would cause an operating pump to stop.

While most logged error conditions are self-explanatory, some are explained in additional detail below.

12.2.2.1 Soft Limit Warning

A soft limit is a stroke position that is outside the normal operating stroke area. A soft limit warning is usually the result of the pump not being able to adjust quickly enough to an operating condition. A soft limit will not stop pump operation. For example, if a pump is maintaining pressure at max extend and the pressure suddenly drops, the pump will extend a little further than it would normally and enter the soft limit. If a soft limit is reached, the pump controller’s software keeps the pump operating only in the direction away from the soft limit. Since the piston stroke is very limited at this point, some variation in pressure or flow rate may occur. Soft limit errors do not cause damage to a pump and will not stop a pump’s operation. If a soft limit occurs, however, the user should try to determine the operating conditions that led to this error in order to avoid a soft limit error in the future. To move a pump cylinder out of the soft limit area, use Independent Constant Rate mode.

12.2.2.2 Communication Cannot Be Established

In order for PumpWorks to control a user's pump system, communication needs to be established between the user's computer and pump(s). If communication cannot be established between the pump(s) and PumpWorks, do the following:

- First, check the two digit display labeled "Pump Number" located on the pump controller. There is a right digit decimal point, which is located to the right-hand side of the right digit. There is also a left digit decimal point, which is located to the right-hand side of the left digit. The right digit decimal point flashes when signals are being transmitted from the computer to the pump controller. The left digit decimal point flashes when signals are being transmitted from the pump controller to the computer. When viewing the two digit display a user should see both decimal points flashing. If the decimal points are <u>not</u> flashing, there may be a break in the communications cable which carries the signal between the pump and the computer.
- Next check that the computer is properly connected to your pump. To do this, perform the PumpWorks Connection Check found in Chapter 3, Section 3.2.
- Go to PumpWorks main window. From the menu bar, select Communications | View Communication Status.

  After a few seconds the "COM Port Selection for Communication Status" window appears. Click on the COM number that your pump is connected on, then click on OK.

  The PumpWorks Communication Status for Com # window appears. At the top left corner check to see if the serial expander/isolator is present or not present.

  If the expander is present, the problem is between the serial expander/isolator and the pump controller.

  - Check that the data link cable is plugged into "Data Link" on the pump controller and NOT into "Front Panel".
  - Try plugging the pump controller into a different port on the serial expander/isolator. Ports A, B, C or D are possible. Search for pumps again by selecting Communication | Search For Pumps.

  NOTE: Each time you alter any item during this troubleshooting process you need to search for pumps so that PumpWorks can establish communication with the pump(s).

  If the serial expander/isolator is NOT present, then the problem is between the computer and the serial expander/isolator. Check the RS-232 cable, try a different serial port on the computer, or try using a different computer.

12.2.2.3 Errors After Communication Has Been Established

Once communication is established between PumpWorks and the pump controller, the following communication errors may be reported in the error log. These errors are automatically compensated for by PumpWorks, which notes the error and then resends the command again so that no data is lost. If a lot of these errors are occurring, then communication between the pump controller and PumpWorks is significantly slowed down. It is therefore better to discover and correct the source of these errors when possible.

- **Buffer Overrun Error**
  Buffer overrun errors are due to a slow computer. This can be corrected by keeping other programs from operating while using PumpWorks, or by getting a faster computer. When a buffer overrun error occurs, PumpWorks automatically retries and corrects for any dropped communications.

- **CRC Check Error**
  CRC check errors mean the communication line is noisy. Either the data communications cable is too long or it is placed next to a source of electrical interference. Correct the problem and the error should go away. If the CRC check errors continue, however, either the computer's serial port, the serial expander/isolator or the pump is not working on the proper frequency. Try using a different serial port on your computer or a different computer.

- **Incorrect Number of Bytes Received**
  Incorrect number of byte errors can be caused by a slow computer or by a noisy communication line. Noisy lines can be caused by the data communications cable being too long or being too near a source of electrical interference.

- **Input Error**
  Input errors are due to a bad command being received by the pump. Noisy communication lines are normally the cause of this type of error. If an input error occurs, PumpWorks automatically retries and corrects for any dropped communications.

- **No Response from Pump Error**
  This error is most likely caused because the computer is busy with another task. This can be corrected by keeping other programs from operating while using PumpWorks, or by getting a faster computer. When PumpWorks receives no response, it automatically retries and corrects for any dropped communications. It should be noted that the Windows 98 operating system is particularly bad at being able to properly handle communications at times. We can only hope that Microsoft's next operating system will be better.

12.3 CN-6000 Two Digit Display Error Messages

The CN-6000 Pump Controller has a two digit display which is labeled "Pump Number". The two digit display relays information concerning the pump's status. Using either letters, numbers or a combination of the two, the digital display can convey the following errors:

- analog overpressure errors,
- communication errors,
- digital overpressure errors,
- digital underpressure errors,
- driver fault errors,
- malfunctioning controller or power supply, or

- the absence of a driver, motor, sensor or transducer cable.

If no errors are present, the two digit display will display the pump number (1,2,3, and so on).The following two digit display errors are discussed in this section:

- The Two Digit Display Does Not Light, Section 12.3.1
- The Two Digit Display Does Not Complete Its Initial Check., Section 12.3.2
- Pump Controller Diagnostics, Section 12.3.2.1
- Two Digit Display Error Code, Section 12.3.3

12.3.1 The Two Digit Display Does Not Light

If the two digit display does not light when power is turned on to the pump controller, do the following:

- Check that the power cord is fully plugged in.
- Check that power is available to the electric outlet.
- Try turning the pump controller's power switch off and then back on again.

  If the two digit display still does not light, either the power supply or the pump controller has failed and needs to be replaced at Chandler Engineering. The power fuse for the power supply is not user-replaceable.

12.3.2 The Two Digit Display Does Not Complete Its Initial Check.

Each time a segment of the two digit display lights during the initial pump start-up, a specific aspect of the pump controller is being checked. If the two digit display fails to complete its initial pump start-up check, that is an indication that the pump controller's printed circuit board needs to be replaced at Chandler Engineering.

Watch the two digit display when you turn on your pump.

- The first thing that will happen is all segments of the display will light at once, briefly.
- Next, the display should flash the boot version number.

12.3.2.1 Pump Controller Diagnostics

The basic pump controller diagnostics are performed next. The controller begins testing itself. If a test fails, the display will freeze. Report this to Chandler Engineering technical support.

The right hand digit will light, the left hand digit will not. One segment of the right hand digit will light at a time, starting with the top segment as shown in Figure 12-1 below. One segment lights, then a second segment lights, then a third, and so on. Each segment that lights is a confirmation from PumpWorks that a specific aspect of the pump controller is operating correctly.

```
1st     2nd     3rd     4th      5th      6th      7th

___     ___     ___     ___      ___      ___      ___
           I       I       I        I     l   I    I__ I
                   I    ___I     I___I    I___I    I___I
```

Figure 12-1

The segments on the right hand digit represent the following tests performed by the pump:

Segment 1: RAM test OK

Segment 2: Move code OK

Segment 3: Boot CRC OK

Segment 4: Block 1 CRC check

Segment 5: Block 2 CRC check

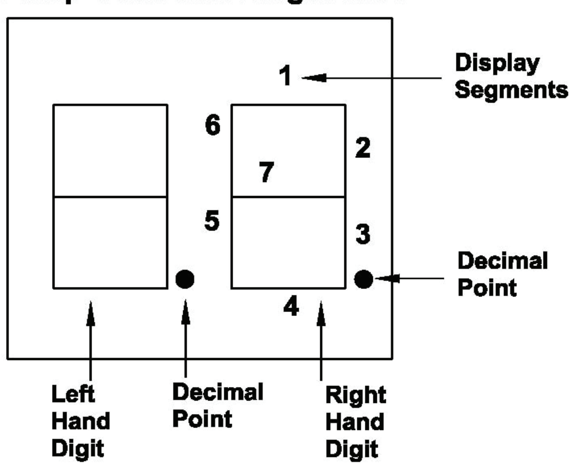
Segment 6: Block 3 CRC check

Segment 7: Code CRC OK, Jump to program

If segments 1, 2, or 3 do not light, call Chandler Engineering.

If segments 4,5,6,or 7 do not light, start PumpWorks and load the program code. PumpWorks will know that the program is bad and will prompt the user for the program file name.

Two Digit Display
Pump Controller Diagnostics



12.3.2.2 PumpWorks Diagnostics

The PumpWorks diagnostics, also called the software diagnostics, are performed next. The left hand digit will light, the right hand digit will not. The left hand digit will display number

1, then 2, then 3, then 4, then 5, then 6, then 7. Each number that lights is a confirmation that a pump controller software function is operating correctly. The numbers will flash quickly.

The numbers on the left hand digit represent the following tests performed by the controller's software:

0,1,2 = load program into RAM and initialize variables

3,4 = calibrate pressure channel A to D for cylinder A and B

5,6 = check and set pump cylinder location for cylinder A and B

7 = all tests passed, accept commands from PumpWorks

In the final step, "do" will flash alternately with "0". The "do" stands for digital overpressure. As a safety precaution, each time a pump is powered on the safety pressure is set at -50 PSI. The user must set the safety pressure to a valid operating value each time each time the pump is powered up. The "0" means the pump has not yet been assigned a pump number by PumpWorks. As soon as the pump is installed onto PumpWorks, the "0" will be replaced with the pump number.

12.3.3 Two Digit Display Error Code

Following is a list of letters that can appear on the two digit display, written in block style. A brief definition follows each error code.

AO Analog Overpressure Error
• pressure transducer signal abnormally high
• transducer or transducer cable failure
• analog to digital converter problem

CE Communication Error
• unable to decode communication from computer

DC Driver Cable Error
•driver cable not connected

DE Driver Status A or B
• the motor driver has a fault--possibly overheated or shorted
•turn off power to reset driver

DO Digital Overpressure Error
•cylinder pressure exceeds safety pressure (When a pump is powered on, it will have this condition until the safety pressure is set.)

DP Driver Power
• the motor power supply has shut down
•turn off power to reset power supply

DU	Digital Underpressure Error • pressure transducer signal abnormally low, • transducer or transducer cable failure, • analog to digital converter problem
ES	E Stop • user has activated the emergency stop signal on the user interface connector
LE	Low Side Driver Error • a valve wire is not connected (pilot solenoids on valves)
PC	Pressure Transducer Cable Error • pressure transducer cable not connected
PE	Motion Error (Position Error) • malfunctioning linear motion sensor •drive train problem--slipped gear or ball screw problem
SC	Sensor Cable Error • sensor cable not connected
SL	Soft Limit Warning •stroke position outside normal bounds •malfunctioning motion sensor
UC	Valve Cable Error • valve cable not connected

To correct cable errors, locate the cable that the problem is reported on and make sure it is fully plugged in. For driver or power supply shutdown error, try powering the pump off and then back on. These devices have overload protection circuits that shut them down when overloaded and are reset when powered on.

12.4 Air Supply Problems

The valves on the 6000 Series Pump System need a CLEAN, DRY air supply, between 4.5 and 6.9 bar (65 to 100 PSI) to properly operate.

12.4.1 No "Air Escaping" Sound When Valves are Opened and Closed

The most likely cause of this problem is that the air supply is not dry, so the pilot solenoids have rusted and stopped switching. To check this, turn off your air supply, unplug your air line and check if there is any water in the line. If the pilot solenoids have rusted and no longer operate, they will need to be replaced.

The other cause of this type of problem is the air pressure is too low or too high to operate the valves. Use a pressure gauge to determine the air pressure. If the air pressure is too low:

- Check that your air tubing has been connected properly,
- Check that the air supply is on, and
- Check that the air tubing is not clogged.

If the air pressure is too high (more than 6.9 bar (100 PSI)), install an air regulator to limit the pressure.

12.4.2 Constant "Air Escaping" Sound

If you hear a constant "air escaping" sound when the valves are not being operated, then it is likely there is an air leak. The pilot solenoid valves should not leak air when they are operating properly.

- Check each air fitting to see if any fitting is loose.
- Check each air tube to see if it is cracked.
- Try using "Snoop" (soap and water solution) to detect small leaks by making bubbles appear.
- Sometimes a pilot solenoid will get stuck part way open or part way closed and allow air passage. Try opening and closing the valve to get the pilot solenoid unstuck and moved to a fully open or fully closed position. Opening and closing a pilot solenoid a few times may free up a stuck solenoid. If this doesn't work, the pilot solenoid may have to be replaced so it does not constantly leak air.

12.5 Fan Does Not Run

The fan must ALWAYS be running when the pump cylinder is operating. If the fan does not come on when the motor driver is powered on, or if it stops while the pump is running, stop the pump cylinder immediately. Contact Chandler Engineering for a replacement fan.

12.6 Fluid Leaks

Although Quizix pumps are made to a high standard, a fluid leak can occur. The following sections explain what to do if you have a fluid leak.

- Leakage Basics, Section 12.6.1
- Leak Testing, Section 12.6.2
- Does Your Pump Have a Fluid Leak?, Section 12.6.3
- Finding Your Leak, Section 12.6.4

12.6.1 Leakage Basics

The Q6000 is a pump system that uses a piston to push fluid out of a cylinder barrel. The fluid is contained in the cylinder barrel by a seal, which has a static connection to the cylinder barrel and a dynamic (moving) interface to the piston. For a continuous flow system, valves,

pressure transducers and interconnecting tubing and fittings are also required to control the flow of fluid. Any of these components can be the source of a fluid leak.

Detecting a leak can sometimes be difficult. Large leaks in the range of 0.01 ml per minute are easy to find since these can be observed by the eye (a typical drop of liquid is about 0.05 ml) or detected with a bubble (snoop) leak detection solution for gases. Smaller leaks in the .01 to .001 ml per minute range become more difficult since fluid can evaporate as fast as it leaks. Care and patience are needed to find leaks in this range. If you are using brine, a salt deposit residue is a clear indication of a leak. Extreme care must be used to find leaks below 0.0001 ml per minute, since many other factors need to be considered.

12.6.2 Leak Testing

The 6000 Series Pump System can trace volume changes very accurately. This volume measurement, combined with the pressure measurement, can be used to detect fluid leaking from the pump system.

- To detect a leak in this way, the pump cylinder can be pressurized to a set pressure and then stopped, and the pressure can be recorded as a function of time. This is a truly static leak test in that the piston is not moving with respect to the seal.
- Alternately, the pump cylinder can be operated in constant pressure mode and the volume recorded versus time. This is a quasi-static method in that the piston will be making slight motions as the pressure control algorithm operates.
- A third method uses gear mode, without valves, to push fluid from one pump cylinder into the other. This is a truly dynamic leak test of the pump cylinders.

Temperature must be precisely controlled in order to know if a small leak is real or not. Depending on the compressibility and fluid used, temperature changes cause variation in pressure in a closed fluid system. In a typical pump cylinder, pressure can change 50 to 100 PSI per degree C. Therefore, if you want to detect small leaks, temperature must be held steady, and even then long tests are usually needed to get reliable data.

Not only does external temperature need to be controlled, time must be allowed for thermal equilibrium of the fluids in the pump system. When a fluid is pressurized, it heats up. This heated fluid inside the pump cylinder then starts to cool down to the cylinder barrel temperature. As it does this, the fluid contracts and the pressure falls. This fall in pressure can look like a fluid leak. Allow at least 15 minutes after pressurization for the temperature to equalize.

When looking for small leaks, there are several other considerations to be aware of. The seals and o-rings in the system are elastic. With pressure and time they tend to creep, which increases volume in the cylinder barrel and looks like a fluid leak. This problem is most noticeable when a new seal or o-ring is installed, but can also show up in dynamic tests as the seals and rings wear and lose material to the outside.

Other factors that can affect the results of leak tests include pressure transducer drift, fluid property changes, gas bubbles, and fluid permeation or absorption into the seals and o-rings.

12.6.3 Does Your Pump Have a Fluid Leak?

A pump cylinder can be checked for fluid leakage by following the steps below:

1. Fill the pump with the fluid to be tested
2. Set the pump to constant pressure independent mode.
3. Close both the fill and deliver valves.
4. Select an appropriate test pressure.
5. Start the pump.

Next the pump will pressurize and hold the set pressure. After allowing for thermal effects to subside (about 15 minutes) set the volume of the pump cylinder to zero and watch for fluid volume changes. If the pump continues to move forward, then there is a leak. By logging the volume versus time, the leak rate can be determined. Any changes in temperature during this test time will also show up as changes in volume, so care must be used in analyzing this data.

12.6.4 Finding Your Leak

If you detect a leak, then the next step is to find it. The most likely places for a leak to occur are at the piston-seal interface or in the valves. Seal leaks are most often caused by particles in the fluid scratching the lips of the seals. If fluid is leaking out of the bottom of your pump cylinder, you are very likely to have a seal leak. If a fluid leak is present and no evidence of fluid leakage is present at the valve leak ports, or around any of the fluid tubing fittings, then most likely there is a seal leak. To test more thoroughly, try removing the fitting at the front of the cylinder barrel and replacing it with a plug, then running the leak test again. If you still have a leak, then it is almost for sure a piston seal leak. Please refer to Section 11.2.2 "How to Change the Seals". If the leak is no longer present when this test is run, then the leak is most likely in the valves.

Seals generally will have a lifetime of about 1 year. With certain fluids, seal life decreases. To increase the life of the seals, the following can be done:

- Pump clean fluids whenever possible.
- Filter the fluid being pumped so there are few, if any, particles in the fluid.
- If you are pumping brine or other corrosive fluid, do not let it sit in the pump for a long time. Flush the pump with a clean fluid after each use.

12.7 No Fluid Is Being Delivered

If no fluid is being delivered during pump operation, try the following:

- Make sure the fluid inlet plumbing is connected to a fluid source. If using an inlet filter, try removing it temporarily.

- Check if the fluid inlet or fluid outlet plumbing is clogged, resulting in no fluid entering the pump. If you suspect a clog, disconnect the tubing and check that fluid can easily flow through the tube in question.

- Check for loose fittings on the fluid inlet side. Check to see if the tubing has a hole or crack which would cause air to be drawn into the tube instead of fluid.

- Check to see if the fluid is too viscous, or thick, to be pulled into the pump. This can be checked by watching the pressure of the pump cylinder as it starts to fill. If the pressure drops too much, the fluid will cavitate and not get pulled into the pump. Typically pressure drops only 1 to 2 PSI when the pump cylinder is pulling in fluid. Water will cavitate if the pressure during filling drops more than 6 PSI.

- Check the motion of the piston by doing the following:
    1. Set the operating mode to Independent Constant Rate.
    2. Set the flow rate to 50% of the maximum flow rate of the Q6000 model you are using.
    3. Set the cylinder direction to either extend or retract, whichever is appropriate.
    4. Open the fill valve.
    5. Start the pump cylinder and watch the physical piston position indicator through the side cover for proper movement from max retract to max extend. If there is no piston movement, contact Chandler Engineering technical support.

- Make sure the valve assembly is installed in the correct position and that all valve fittings are securely tightened.

- Check the transducer and valve cable. Make sure it is properly connected to both the transducers and the pilot solenoids. Check that the fill and deliver valves are operating properly by performing the "Valve Check" in Section 3.3.

- Check that the air pressure for the valves is between 60 and 100 PSI. If the air pressure is too low or too high, the pilot solenoids can malfunction.

- Is the air clean and dry? The pilot solenoids are constructed of soft magnetic iron and can easily rust when exposed to moisture.

12.8 Piston Motion Errors

In most cases, piston motion problems will cause PumpWorks to report a piston motion error. If a motion error occurs, the user needs to determine if the piston is actually moving or not. This is done by looking through the pump cylinder side cover. The following piston movement errors will be discussed in this section:

- Motor Running, No Piston Movement Detected Error, Section 12.8.1

- Motor Stall Error, Section 12.8.2
- Piston Moves, But Does Not Complete Its Stroke, Section 12.8.3

12.8.1 Motor Running, No Piston Movement Detected Error

A Motor Running, No Piston Movement Detected error is generated when the motor is running but no motion is detected by the sensor board. This can be caused by a motor stall or faulty motion sensor. To check these conditions, start the pump cylinder and watch the physical piston position indicator through the side cover.

- Double-check that you are watching the physical piston position indicator for the pump cylinder that has been started on PumpWorks. For example, if you started Cylinder 1A, then make sure you are looking through 1A's side cover.
- Make sure that the flow rate that the pump cylinder is operating at will provide observable motion. Take into account the flow rate units, either ml/hour or ml/minute.
- If the piston still cannot be observed moving through the side cover, contact Chandler Engineering technical support.

12.8.2 Motor Stall Error

A motor stall error occurs when the power needed to move the piston exceeds what is available from the motor. The motor then slips, with a fast, zipping noise.

If the cylinder direction was extend, then:

- Check if the current pressure exceeds the pump's maximum pressure.
- The piston may not be fully seated into the ball screw and has hit the top of the cylinder barrel.
- The ball screw drive may be blocked by something.
- Motor or driver may be malfunctioning.

If the cylinder direction was retract, then:

- Motor or driver is malfunctioning.

12.8.3 Piston Moves, But Does Not Complete Its Stroke

If the piston is moving normally in most of the operating range, but gets stuck at one end or the other, then check the following.

- The piston and piston holder may not be fully tightened into the end of the ball screw.
- The motion of the ball screw drive may be blocked by a foreign object.
- The seal back-up ring may have clamped down on the piston causing excessive friction.
- The motion sensor may be malfunctioning.

12.9 Pressure Problems

The pressure transducers on the 6000 Series Pump System are essential for proper pump operation. Any problem with the transducer will mean that the pump will not operate the way it is supposed to. Several types of problems with the pressure transducers are covered below.

12.9.1 Pressure Transducer Errors

If the pump reports a pressure transducer cable error, this means that the cable from the pump controller to the transducer is no longer connected properly and needs to be fixed. To correct this problem, do the following:

- The transducer and valve cable must be inserted into the transducers properly. Check the 6-pin circular connector at each transducer.
- Check if the cable has been worn or cut. If there is an analog overpressure or digital underpressure reading, this can be the result of a controller failure, a transducer cable problem or a transducer failure.
- Check the transducer cable first and then try swapping transducers and transducer cables. If there is a faulty component, it will need to be replaced.

12.9.2 Pressure Does Not Increase Within 30 Seconds

If the pressure does not start to increase in a pump cylinder when it is running, then the most likely cause is no fluid in the pump, which can be caused by any of the following:

- A leak in the inlet fluid tubing allowing air to be pulled into the pump cylinder instead of fluid.
- The fluid inlet tubing is clogged, preventing fluid from entering the pump cylinder.
- Fluid is too viscous, or thick, to be pulled into the pump

Other causes of this problem could be that the fill valve is leaking, the cylinder seal is leaking, the pressure transducers are cross wired or the fluid being delivered is leaking out some where in its fluid path.

Open the fill valve and listen for pressure being released. If there is pressure being released, you probably have a pressure transducer failure. NEVER operate the system AT ALL if you have any reason to believe a transducer has failed.

12.9.3 Pressure Overshoots Setting in Constant Pressure Mode

Pressure control in a constant pressure mode is set by the proportional and differential gain constants. Please refer to the PumpWorks User Manual to learn how to set the servo gains for desired pressure operation. This problem can also be caused by having a gas-liquid mixture. The piston will accelerate to compress the mixture and shoot past the set pressure before it can slow down. If you must use a gas-liquid mixture, you will need to carefully set the servo constants to keep the pump from exceeding the safety pressure.

12.9.4 Pressure Is Not Constant in Constant Pressure Mode

Pressure control in constant pressure mode is set by the proportional and differential gain constants. Please refer to PumpWorks User Manual to learn how to set the servo gains for desired pressure operation.

12.10 Valve Problems

The air actuated flow control valves are a vital part of the operation of the 6000 Series Pump System. They control the direction of the fluid flow. The valves used on the pump system are highly reliable. However, as with any mechanism, problems can occur. In this section we will present some basics on how the valves are used in the pump system. Refer to the Vindum Engineering Valve User Manual, included with your pump, which has detailed maintenance and troubleshooting information regarding the valves.

12.10.1 Valve Cable Connection Check

The transducer and valve cable connects the pump controller to the pilot solenoids. Make sure each cable branch with a 2-pin connector is properly connected to the pilot solenoid with the same number.

12.10.2 Checking Your Air Supply

The valves used in Quizix pump systems are air actuated. Air is taken into the system through the air inlet and distributed to the pilot solenoid manifolds. The pilot solenoids then distribute and control the air flow to the valves.

Nylon tubes connect the pilot solenoids to the valves. Check the tubing for cracks, clogs, or other problems. Check the color-coded fittings at both ends to be sure they are properly connected; the colors should match the fittings at both ends of the tubes.

12.10.3 Air Supply Requirements

IMPORTANT: Although the 6000 Series Pump System uses very little air, the air supply that is used **MUST** meet the following conditions:

- The air must be clean.
- The air must be dry. Moisture in the air supply will cause the pilot solenoids to rust and malfunction.
- The air must be between 65 to 100 PSI (4.5 to 6.9 bar). If air pressure exceeds this, the pilot solenoids may stop working.

12.10.4 Checking Your Air Supply Connection

To check the air supply connection, first identify the air inlet. Make sure a 1/4” tube is inserted into the air inlet fitting, and that it is tight and cannot be moved. Attached to the other end of the tube should be your pressurized air source. If your air supply has a switch to turn it on, make sure it is turned on so that air will be supplied to the pump. Note that 6 mm tubing

will also work, in most cases. Nylon tubing is the recommended material for the air tubes, however, other materials will work.

12.10.5 Pilot Solenoid Check

Pilot solenoids are used to open or close the fluid pathways inside the valves. The pilot solenoid manifold takes in air from the user’s air supply and distributes that air to the pilot solenoids. Please refer to Chapter 3, “Valve Check” for information on checking your pilot solenoids.

12.10.6 Clogged (Obstructed) Valve

It is possible for the valve inlet to become clogged with particles from the fluid being used. If a valve becomes clogged, then fluid can no longer be pulled into a pump. This can be detected by watching the pressure in the pump cylinder as the piston retracts. The pressure should not drop more than 1-2 PSI. If it drops more than this, the fluid may not be getting into the pump cylinder due a clogged inlet tube or valve. The outlet side of the valve is unlikely to clog due to the fact that the pump can generate high enough pressures to push most particles out of the valve. It may be possible to clear a clog on the inlet side by using the pump to push the particles out of the inlet. It would be advisable to clean all tubing and components thoroughly if a clog has been encountered so that this problem does not reoccur.

12.10.7 Valve Leaks Fluid When Closed

There is a possibility that the valve will not fully close and fluid can leak across the closed valve. If this occurs, the valve will not hold pressure. If you pressurize a pump and it is not holding pressure, fluid may be leaking out of a seal, or it could be leaking out across the valve. One way to check if a valve is leaking fluid is to swap valve A and valve B. Refer to the Valve User Manual for maintenance and repair instructions.

12.11 Software Updates

The operation of the 6000 Series Pump System is controlled by two separate software programs: PumpWorks 95-NT, which is stored on the user’s computer, and the pump controller software which is stored in the pump’s controller. New versions of software are periodically released. Problems detected after a software version is released, are resolved in later software versions.

To make sure you have the latest software version available for your pump, check which version you have. Go to PumpWorks main window. On the main menu bar select Help | About PumpWorks. The version of PumpWorks 95-NT that is installed is displayed in the top center box after the words “Software Version”. This software runs on the computer and is what you see on the computer screen and interact with.

The pump controller is also running a program. The controller software version is shown next to “Controller Version”. The last two digits are a special part of the controller software called the “boot code”. The rest of the digits are the controller software version. Next you need to check which is the latest version of PumpWorks available. To do this contact Chandler Engineering, either by phone or by going to our website at: http://

www.chandler.sales@ametek.com. Please refer to the PumpWorks User’s Manual for software update procedures.

Appendix A: How to Attach a Fitting to Your Tubing

CAUTION

To keep dust out of the fluid plumbing, a red plastic plug has been inserted in the open hole of the fluid inlet and the fluid outlet. Remove and discard these two red plastic plugs before operating the pump.

The tube's outside diameter must be 1/8" (.125 +/-.001); 3 mm tubing WILL NOT work. Cut tubing. Allow an extra 1/2" (12 mm) in length for proper fitting engagement. After cutting the tube, deburr--get off any sharp edges or corners from the tube--before installing the gland and sleeve. Use air or fluid to clean the tubing inside and out to remove any particles left over from cutting.

1. Lubricate male threads. (Lubrication is not necessary if tube nut has Bonded Dry-Film Lubricant.) Slip gland and sleeve onto tubing. Make sure larger end of sleeve is toward gland. Push tubing into valve or fitting until it bottoms. If your usage will permit it, a slight amount of inert grease on the nose of the compressions sleeve will improve sealability.

2. Tighten gland until sleeve begins to grip tubing.

3. Note starting position of wrench. Tighten gland approximately 1-1/4 turns for the speedbite® type connection.

A.1 Completed Connection

Note the condition of the sleeve and tubing after completion of "sleeve seating". The sleeve has cut into the tubing as it moved forward into the tapered seat, upsetting material ahead of it and establishing a shoulder on the tubing to provide positive mechanical support for the tubing end-load. A properly seated sleeve cannot be displaced back and forth along the tubing but may be rotated slightly around the tubing.

A.2 Re-assembly

Reassemble a connection by inserting tubing, with attached sleeve and gland, into valve or fitting. Tighten gland "finger-tight". Tighten gland with a wrench approximately 3/8 of a turn for a gas-tight seal.

After frequent reassembles, it may take less than 3/8 turn to effect a gas-tight seal, and as little as 1/8 of a turn may be sufficient. DO NOT OVERTIGHTEN. Overtightening will deform the sleeve and degrade the sealing ability of the fitting.

This page intentionally left blank.

MASTER GLOSSARY

AC line noise rejection	This term refers to the reduction of the magnitude of voltage spikes and noise on an AC power line. Some uninterruptible power suppliers and surge suppressors are able to reduce voltage spikes and noise to help protect the electronic equipment connected to them.
A/D converter	An A/D (analog to digital) Converter takes an analog electrical signal and converts it to a digital signal that can be displayed as a number. An example would be to take an electrical signal from a pressure transducer and convert that signal so the pressure is displayed as a number on the computer.
acoustic separator	This is a device that uses ultrasonic signals to measure fluid volume. PumpWorks software allows for the pump system to interface with an acoustic separator.
activated	To put into action, or, to start working.
active pump cylinder	The pump cylinder that is delivering fluid to or receiving fluid from a users experiment. The deliver valve must be open and the fill valve closed.
adjustable face spanner wrench	A tool, supplied with your system, that is used to loosen and tighten the cylinder barrel retaining ring, and remove or install the seal retaining nut.
aflas	An elastimer seal material used in high temperature systems. Aflas works especially well with oil industry fluids.
air actuated	The operation is begun by a force of air. This is sometimes referred to as pneumatically actuated.
air inlet	The connection port where the user’s air supply comes into the pump system.
air supply	Either an air compressor or bottled gas, supplied by the user, for operating the air actuated valves.
Allen wrench	This tool is used to tighten or remove six sided Allen-head screws. It is also known as a hex wrench.
Allen-head screw	This is a screw with an indented six sided head. It is also known as a socket head cap screw.
ambient temperature	Temperature that is equal to the temperature in the surrounding room.

amplifiers	A device which increases the magnitude or amplitude of a signal, such as voltage from a pressure transducer.
anti-seize compound	This is a grease-like mixture applied to the threads of metal nuts which prevents them from locking, or seizing, together so they can be separated in the future.
arrow keys	These keys are located on your computer keyboard. They are arrows that can move your computer cursor in any of four directions.
atmosphere	The air that surrounds you.
atmospheric pressure	The pressure that is present in the air, or atmosphere, around you. Normal atmospheric pressure is about 1 bar or 14.7 psi.
Auto Op or automatic operation	A feature of PumpWorks software which allows for the pump system to be operated automatically.
auto ramping Operation	See Ramping Operations
Automatic Volume operation	Using PumpWorks software, the pump cylinder(s) will stop pumping after a specified amount of fluid has been pumped.
automatic time operation	Using the PumpWorks software, the pump cylinder(s) will stop pumping after a specified amount of time has passed.
auxiliary A/D channel	Quizix pump controllers and PumpWorks software have auxiliary, or spare A/D channels that can be connected to your pump system to display signals such as pressure and temperature.
auxiliary digital input signals	Quizix controllers and PumpWorks software have the capability of sensing and displaying user logic signals, such as from a contact opened or closed by a microswitch.
auxiliary valve cable	This connects the pump controller to the auxiliary pilot solenoid valve manifold.
auxiliary valves	The Quizix controller and PumpWorks software have the capability of operating additional valves that the user may add to the pump system.
auxiliary valve window	This PumpWorks software window controls any auxiliary valve(s) the user has added to the pump system.

back-drive — If the pump cylinder pressure is above a critical pressure (which varies from 1,000 to 5,000 psi depending on pump type) **and** power is lost to the motor driver, pressure forces on the piston are so strong that the ball screw will rotate as the piston is pushed backwards. The pump cylinder pressure will then drop until the pressure is reduced below the force necessary to back-drive the piston.

ball nut — The ball nut works with a ball screw to convert the rotary motion of the motor and harmonic drive into linear motion for the piston.

ball nut assembly — This includes the Ball nut, ball screw, and the mechanical parts which support the ball nut and ball screw, such as the flexure and ball nut flange.

ball screw — The ball screw has threads on which the ball nut turns. Together the ball nut and the ball screw convert the rotary motion of the motor and harmonic drive into linear motion for the piston.

ball screw pitch — The ball screw is machined with a specific number of threads per inch or pitch. The ball nut will advance this distance for each revolution of the ball screw. For example, if the ball screw has 8 threads per inch, then the ball screw will require 8 full rotations in order for the ball nut to advance one inch.

BAUD rate — This is the speed of the electrical communication signal used by the controller and the computer. For example is 28.8 kilobaud is twice as fast as 14.4 kilobaud.

bearings — Inside of the pump cylinder are radial bearings and thrust bearings which hold the ball screw in place, but allow it to rotate.

bidirectional — Capable of operating in two directions, or, to go back and forth.

cable clips — The metal clips mounted on an assembly (controller or driver) that lock around the end of the cable connector to keep the connector and attached cable firmly in place.

cable connection sensing — This is a controller and pumpworks software safety feature that detects the presence or absence of certain cables in a system.

cable extension — The cables supplied with the pump system can be extended with additional cable.

cable retainers — A metal clip on each side of the cable connector which allows the cable to be locked firmly in place with cable clips.

calibrate	To check or adjust a measuring instrument so it remains accurate.
cam rollers	A cam roller is located on each side of the pump cylinder and allows the user to view the position of the piston.
capillary viscometer	A tube that develops pressure drop proportional to flow.
cascade	The computer positions all open files so that only the top of each window is displayed.
ceramic	The pistons are made from ceramic, a material that is almost unscratchable and highly corrosion resistant, but is slightly brittle and breakable.
color coded	Each pump cylinder has a different color band which corresponds to the color used to display information about that pump cylinder in the pumpworks software.
communications port	The serial data cable from your controller plugs into the serial communications port connector on the back of your computer. It is sometimes referred to as a com port or comm port.
component	One part or piece of the pump system.
Com port	See communications port.
compression ring	The compression ring holds the safety rupture disk in place, inside of the safety rupture disk holder.
concave	The inside hollow of a curve, as in the inside of a bowl.
configuration	The particular arrangement of the parts that make up your pump system.
Constant Delta Pressure Mode	The system will pump fluid at a constant pressure differential across a core sample. To maintain this constant pressure differential the fluid delivery rate of the active pump cylinder will change, as needed.
Constant Pressure Mode	The fluid pressure for the active pump cylinder remains the same, at a user selected value. To accomplish this the fluid delivery rate of active pump cylinder will change, as needed.

Constant Rate Mode	The active pump cylinder's fluid pump rate remains constant at the user specified value. The active pump cylinder's fluid pressure is set by the system flow resistance. The system flow resistance is the degree of ease or difficulty at which fluid will pass through a system.
continuous flow pumping	The pump system can pump fluid for any length of time without stopping. This is accomplished by two pump cylinders working together for one fluid. One pump cylinder, the active cylinder, will pump, or deliver, the fluid while the other pump cylinder, the standby pump cylinder, fills and pre-pressurizes. Pulseless continuous flow is achieved by precisely coordinating the switching between the two cylinders.
controller fuse	An electrical safety device that protects the electric circuit going to the controller by melting when overloaded by a malfunction.
controller on/off switch	This on/off toggle switch allows power going to the controller to be turned on or off.
controller option switches	Four sets of eight individual on/off switches located on the back of the SC-2400 controller. These switches are preset by the manufacturer and set up the pump cylinder configurations.
controller serial number	Located on the rear panel. This tells you the version of the controller hardware you are using.
controller side panels	The metal side panels of the controller are available in three types; stand-mounted, rack-mounted or table.
controller status indicators	Four sets of eight each LED Indicators which show the SC-2400 controller is operating.
convex	The outside curve, as in the outside of a bowl.
corrosive fluids	Fluids or chemicals that gradually wear down or eat away at the pump system.
cup-type seals	A seal that looks like a "U" on cross-section.
current value	The value, or number, that is operating, or applies now.
cursor	A blinking element on your computer screen that shows the space where the next letter or number will appear.

cycled mode	Individual pump cylinder operating mode where only one cylinder is used to approximate the activity of a cylinder pair.
cylinder barrel	The round metal part that extends out from the pump housing where the user's fluid is held. The piston enters the cylinder barrel during fluid pumping.
cylinder barrel assembly	The cylinder barrel assembly consists of the cylinder barrel, cylinder seal, seal back-up rings and seal retaining nut.
cylinder support block	Use pump cylinder support block
data log	This PumpWorks software feature allows you to automatically record data from your experiment onto a computer hard disk.
data log parameters	This is where you decide which data items you want recorded in your data log.
debug	A PumpWorks software option that provides access to the Quizix controller so the manufacturer will be able to assist you in resolving any problems that might occur.
deburr	To deburr is to remove any sharp edges or corners
default	The default option is a pre-set value chosen by PumpWorks when the user decides not to pick a different option.
default names	The name given to a pump cylinder, pilot solenoid valve, or auxiliary valve when a pump system is initially shipped from Chandler Engineering. The user can change the default names at any time.
default pressure unit	The unit of measure for the default pressure is PSI, or pounds per square inch.
default rate unit	The unit of measure for the default rate is in milliliters per minute.
deliver	To pump or push fluid from a pump cylinder into a user's experiment or sample.
deliver valve	This valve controls the flow of fluid from the pump cylinder to a user's experiment, or sample.
delta pressure	The measured amount of pressure, or force, across a section or portion of the system.
depressurize	To reduce the pressure on the fluid inside the cylinder barrel of a pump.

depressurizing	To reduce the pressure inside a cylinder barrel. This is accomplished by retracting the piston, thereby increasing the fluid volume inside the cylinder barrel.
destination	The place or point where the fluid is going.
dialog box	This is a window in the PumpWorks software that contains a form, or checklist, for you to fill out.
differential error	This is the measured rate at which the actual pressure is approaching the set-point pressure.
differential gain or differential servo gain	The amount by which you multiply the differential error to convert it to a rate of change for the pump cylinder so that the actual pressure is matched to the set-point.
digital overpressure	This controller software safety feature causes the cs to stop pumping if the user set safety pressure is exceeded.
digital underpressure	This controller software safety feature causes the pump cylinders to stop pumping if the pressure transducer voltage drops below a factory preset level.
display units and precisions	This PumpWorks software window allows you to choose the unit of measure to use when displaying pressure, rate and volume; and to specify the resolution, or number, of decimal places displayed.
driver	An abbreviation, or shorter name, for the motor driver.
driver fan	The driver fan is located at the end of the driver, next to the heat sinks, and keeps the driver cool during operation.
driver fuse	A safety device containing an element that protects the electric circuit going to the driver by melting when overloaded by a malfunction.
driver on/off switch	This on/off toggle switch allows power going to the driver to be turned on or off.
dual motor driver	The dual motor driver provides the motor drive for two pump cylinders and relays status information to the pump controllers.
dust protection plug	A plastic cover used to protect parts from dust and dirt during shipping.

Dynamic Data Exchange (DDE)	A Windows software capability that allows multiple programs to share data in real time. This capability allows PumpWorks to send data, such as rates or pressures, to one or more programs while allowing another program to control pump operation.
emergency stop switch	This immediately shuts off all pulses to the dual motor driver and will cause a sudden stop of the pump cylinders. This is to be used in emergency only. It is located on the front panel of the SC-2400 controller.
end	A button on the computer keyboard which will take the cursor on the computer screen and move it to the end of the line you are working on.
error	An error is a fault that has happened somewhere in the pump system that requires the user to take action to resolve it before the pump system can be operated again.
error log	This PumpWorks software feature is a time record of the errors that have happened to a pump system.
errors present	This PumpWorks software message means that there is currently an error in the pump system that has not been acknowledged or resolved.
exit options	Some of the PumpWorks software windows have certain options which the user selects to exit that menu, i.e. “Exit, No Change” or “Yes, Accept Change”.
extend	The forward direction for the piston.
extended A/D values	PumpWorks can handle an additional 16 A/D channels if the user adds a special card to their computer.
extending	The action of the piston moving forward in the cylinder barrel which causes fluid to be delivered out of the pump to the user’s experiment.
execute	To begin.
fill	To load fluid into a cylinder barrel as the piston retracts.
fill valve	This is the valve that is between the pump cylinder and the supply of fluid. The fill valve controls the process of bringing the fluid into the pump cylinder.
flexure	A mechanical assembly used to equalize side forces on a ball nut assembly

flow rate	The user specified rate the pump cylinder operates at when operating in a Constant Rate Mode.
fluid inlet tubing	The tubing used to connect the fluid inlet tee to the “fill” side of each valve.
fluid outlet tubing	The tubing used to connect the flluid outlet tee to the “deliver” side of each valve.
fluid tight	No leaks occurring in the system. The fluid is contained within the pump system without escaping.
fluid tubing	The tubing which carries the fluid through different parts of the pump system.
fluid plumbing	This consists of fluid tubing, tees, ferrules and nuts.
fuse	An electrical safety device containing an element that protects an electric circuit by melting when overloaded by a malfunction.
fuse holder	A mechanical part that contains a replaceable fuse. It is located next to the power cord connector.
geared mode	A pumping mode that operates two pump cylinders so they move in equal, but opposite directions, at the user set rate. At the end of the piston stroke, both pump cylinders change direction simultaneously (at the same time) and continue to run at the set rate. This mode does not provide pulseless fluid flow.
governs	To control or dominate.
QD fitting or quick disconnect fitting	This quick disconnect plastic fittings, which are located on the pilot solenoids and the CV valves, are used to connect the air lines necessary to operate the valves.
guide rail roller surface	The top surface of the guide rail, where the cam rollers move, or roll, on the guide rail.
hard limit switch	A switch on the pump cylinder that stops the pump controller from moving the piston in either direction. This is a back-up safety feature that normally will not be activated.
hastelloy	This is a metal alloy that is highly corrosion resistant.
HC	This is an abbreviation for hastelloy
heat sink	A metal part, with fins or ribs, that carries excess heat away from the heat source. The SC-220 dual motor driver and some pump motors use heat sinks.

hierarchy	Ranked according to importance.
holding extend	This Pumpworks software motion status message means that a pump cylinder is operating and the piston is extending at zero speed. When the rate becomes higher than zero (non-zero) the piston will extend.
holding retract	This Pumpworks software motion status message means a pump cylinder is operating, and the Piston is retracting at zero speed. When the rate becomes higher than zero (non-zero) the piston will retract.
home	A button on the computer keyboard which will take the cursor that is on the computer screen and move it to the beginning of the line you are working on.
host link	This is a data link which can be used to link the pump system computer with another computer. With such a link, a user can export system data to a second computer for real-time analysis while an experiment is running or use a second computer to control the pump operation.
host link communications protocol	The set of rules the user needs to follow to read data and set data over the host link.
independent cylinder operating mode	One pump cylinder operates by itself and is limited by the single stroke fluid volume. Independent cylinder operating modes are not capable of pulseless continuous fluid flow of more than one stroke volume.
independent constant delta pressure	One pump cylinder operates by itself to maintain a constant pressure differential across a portion of a fluid path by changing the fluid delivery rate as needed. Continuous operation is limited to a single stroke fluid volume.
independent constant pressure	One pump cylinder operates by itself to maintain constant fluid pressure at a user selected value. To accomplish this the fluid delivery rate of the pump cylinder will change as needed. Continuous operation is limited to a single stroke fluid volume.
independent constant pressure cycled	A single cylinder cycles between constant pressure operation and refilling. Continuous flow is approximated by automatically refilling after each stroke volume is used up.
independent constant rate cycled	A single cylinder cycles between delivering and refilling. Continuous flow is approximated by automatically refilling after each delivery stroke and then restarting fluid delivery.

independent constant rate operation	One pump cylinder operates by itself at a user specified constant rate. Fluid pressure will vary determined by fluid resistance in the fluid path. Continuous operation is limited to a single stroke fluid volume.
internal offsets	An automatic pressure transducer calibration feature used with recirculation systems. It is available for viewing only when in the recirculation mode.
interrupt request	A PumpWorks software communication method. An example is when the controller sends information to the PumpWorks about a pump cylinder, it first must request to interrupt the computer's current task.
kPa	This is an abbreviation for kilo pascals, which is a unit of measurement for pressure.
logging interval	Data will be taken at a user specified interval, or time span, and recorded in the PumpWorks software data log file.
lubricate	To apply a liquid to the surface to reduce friction.
main menu bar	This is the rectangular shaped bar that is horizontal across the top of the PumpWorks software main window and contains key words for the pull-down menus.
main window	This screen appears each time PumpWorks software is started. It displays information about each pump cylinder and allows for the user to read data and set operating parameters.
manifold	This supplies air to the Pilot Solenoids which actuate the CV valves.
max extend	See maximum extend.
maximum extend	The furthest, or maximum, that the piston can move during normal operation in the forward, or extend, direction.
maximum value	The highest number, or value, that can be entered.
max retract	See maximum retract.
maximum retract	The furthest, or maximum, that the Piston can move during normal operation in the backward, or retract, direction.
mechanical subcomponents	There are subcomponents, or smaller parts, that make up a mechanical assembly of the pump.
metal ferrules	Metal compression rings used to attach teflon tubing to air actuated valves in high temperature systems.

minimum value	The lowest number, or value that can be entered.
modes	See Operating Modes
modular power cord connector	A modular power cord connector which allows electrical power from different countries to be plugged into the same device.
motion status	The motion status indicates what the piston is doing at any given time. The display field for motion status is located at the top of the main window below the “Cylinder” title.
motor assembly	This includes the stepper motor, motor cable, cable connector, motor adapter housing and associated parts.
motor cable	This cable is permanently attached to the motor and connects the motor to the motor driver.
motor resolution (in steps)	This is the number of steps the motor takes to complete one complete turn, or one revolution.
motor shaft	The portion of the motor that rotates.
not inst (not installed)	This message will appear in the motion status field when the controller cannot detect the presence of a pressure transducer, motor driver or pump cylinder. No pump cylinder actions can be taken through the PumpWorks software when a pump cylinder is detected as not installed.
num lock	A key on the computer keyboard which, when pressed, will allow you to use the numbers on your numeric keypad.
numeric keypad	This is located on the right hand side of your computer keyboard. It has numbers, arrows and cursor movement options.
offset	The electrical shift of a signal around the zero reading.
open-end wrench	This is a wrench with a “U” shaped, or open, end that is used to loosen or tighten bolts.
operating mode	This term refers to the way the pumps are operated. An operating mode is a particular configuration, or set-up, that allows the pump system to be operated in a specific pre-determined manner.
operating mode window	This PumpWorks software screen allows the user to select an operating mode and displays which operating mode is currently being used.

operating perameter setup window	This allows the user to change the default value of the return rate multiplier, the return rate minimum, the proportional servo gain and the differential servo gain.
paired constant delta pressure delivery	A pair of cylinders which work together to pump fluid at a constant pressure differential to a core sample. To maintain this constant pressure differential, the fluid delivery rate of the active pump cylinder will change, as needed.
paired constant delta pressure receive	A pair of pump cylinders which work together to extract fluid at a constant pressure differential from a core sample. To maintain this constant pressure differential, the fluid delivery rate of the active pump cylinder will change, as needed.
paired constant pressure bidirectional	A pair of cylinders maintains a constant pressure by either delivering or receiving fluid.
paired constant pressure delivery	The fluid pressure for the active pump cylinder remains the same, at a user selected value. To accomplish this the fluid delivery rate of the active pump cylinder will change, as needed.
paired constant pressure receive	The fluid pressure for the active pump cylinder remains the same, at a user selected value. To accomplish this the fluid delivery rate of the active pump cylinder will change, as needed.
paired constant rate delivery	A pair of pump cylinders delivers fluid at a constant rate by maintaining constant piston velocity. Pressure varies depending on flow resistance.
paired constant rate receive	A pair of pump cylinders receives fluid at a constant rate by maintaining constant piston velocity. Pressure varies depending on flow resistance.
paired cylinder operating mode	Paired modes use two pump cylinders which are automatically controlled to provide continuous pulse-free fluid flow. The active pump cylinder will be delivering or receiving fluid, while the standby pump cylinder will be refilling and pre-pressurizing. Switch-over to the standby pump cylinder is accomplished without introducing pressure pulses into the system to allow pulse-free continuous fluid flow operation.
paired geared mode constant rate operation	A mode that operates two pump cylinders so they move in equal, but opposite directions. At the end of the piston stroke, both pump cylinders change direction simultaneously (at the same time). Geared modes are not pulse-free.

parameters	The conditions the pump system is set to run within.
perpendicular	Crossing at a right angle, or 90 degrees.
Phillips-head screw	This screw head has two lines on its head which cross each other at 90 degrees.
Phillips screwdriver	A screwdriver designed to tighten or loosen Phillips-head screws.
pilot solenoid	An electrically operated air solenoid which controls air flow and is used to open or shut the fluid paths in the CV valves.
pilot solenoid manifold	This part takes in air from the air supply and distributes it to the pilot solenoids.
pilot solenoid assembly	The pilot solenoids, pilot solenoid manifold, and air tubing and fittings.
piston	A cylindrical rod used to displace fluid in the cylinder barrel.
piston carriage	This is a metal part with a cut out area to support the piston inside of the pump cylinder
piston nut	A hexagonal (six sided) metal nut, that is part of the piston holder. The piston nut is used when extracting the piston from they cylinder barrel.
piston position display	A bar graph in the PumpWorks software that shows how far the Piston is inserted inside of the Cylinder Barrel.
piston stroke	The length of travel that the piston can move, either retracting or extending.
pneumatically actuated	pneumatically actuated, or air actuated, means the operation is begun by a force of air.
pneumatic valve	A valve which is operated by the force of air.
positive displacement pumps	A pump where a solid object is used to physically displace the pump fluid.
power connector assembly	The power connector assembly includes a receptacle for the power cord, a fuse holder and a voltage selector in one unit.
pre-pressurize	The process of the standby pump cylinder building up pressure to match the pressure in the active pump cylinder, then staying ready until it is needed. Because the standby pump matches the pressure of the active pump, pressure pulses are avoided during continuous operation.

pressure	A measurement of the magnitude of a force. This can be measured in different units, which include PSI, bar or pascals.
pressure pulse	A change in pressure which lasts a short duration.
pressure transducer	A device that measures fluid pressure and converts it to an electrical signal. This signal is sent to the pump controller for conversion and display as a number.
pressure transducer cable	The cable that goes from the pressure transducer to the controller.
pressure transducer calibration	The process of checking and adjusting a pressure transducer so that its readings are accurate.
pressure units	Units of measure for pressure which include PSI, bar and pascals.
pressurizing	The process of increasing pressure on a fluid. This is accomplished in a pump by extending the Piston, which reduces the volume available to the fluid thereby increasing the pressure.
printed circuit board or PC Board (PCB)	A group of electrical components on a flat board. There are three types of boards included in an SC-2400 controller; rear panel board, Main PC Board and DSSIP Board.
programmed	A set of instructions that allow the computer to operate the pump system.
prompt line	The prompt line is located in the bottom border of the active window of the PumpWorks software and gives you instructions relating to the task at hand.
proportional error	The proportional error is multiplied by a constant (the Proportional Gain) to generate a rate. This rate will change the pump pressure to the set-point value.
proportional gain or proportional servo gain	The proportional gain is a user set constant which is multiplied by the proportional error which generates a corrected rate for maintaining constant pressure. This rate will change the pump pressure to the set-point value.
PSI	This stands for *pounds per square inch* which is a measure of pressure.
pull down menu	When you click on a word in the PumpWorks software menu, a list of choices appear, this is called a pull down menu.

pump body assembly	The pump housing, plus all of the internal components. These include the motor assembly and ball screw/ball nut assembly.
pump controller	The pump controller is an electrical subsystem which directs all pump operations. The pump controller communicates to the user through the PumpWorks software.
pump cylinder	A mechanical assembly that allows fluid to be pumped.
pump housing	The main mechanical body which covers, or houses, the working parts of the pump cylinder.
quizix.erl	The name of a computer file which contains a listing of errors that have happened in the pump system.
quartz transducer	An extremely accurate and stable pressure transducer which can be used to calibrate a typical pressure transducer.
query	A question presented by the computer that requires you to answer or make a choice.
quit option	A feature in the DOS version of PumpWorks which allows you to exit the PumpWorks software.
ramping operation	Using the PumpWorks software, the pump system can change gradually from one flow rate or pressure to another over a user determined period of time.
rate scalers	A PumpWorks software feature that adjusts the fluid rate or fluid volume to account for either expansion or contraction of the fluid as it is heating up or cooling down.
rate units	This is a unit of measure for rate. It is stated in either milliliters per minute or milliliters per hour.
recirculating	To run through the pump system more than once.
recirculating mode	A special pump operating mode where fluid is continuously pumped from a pump cylinder, through a sample and back into another pump cylinder without the fluid being depressurized and without pressure pulses.
recirculating parameters	This PumpWorks software window is where you set your parameters for recirculating mode.
reconfigure	To configure the system again, or to give the computer a new set of instructions to change the operation of the pump system.

reset recirculating mode	This is the only way to properly exit from recirculating operation.
reset volumes	The display volume for any pump cylinder can be set to zero, at any time, using this button.
residue	A deposit that remains on a surface after fluid has been removed.
restore	Brings a window that is minimized, into full view again.
retract	The direction the piston moves when it backs out of the cylinder block.
retracting	The motion of the piston, as it pulls back out of the cylinder barrel to fill with fluid.
return rate multiplier	The return rate multiplier is the number that is used to multiply the set rate to determine the return rate. This number is always 1 or greater, so that the return rate is equal to or faster than the set rate. A faster return rate is used in a pair of cylinders so the returning (stand-by) cylinder has enough time to prepressurize.
return rate minimum	The lowest rate or speed that the standby pump cylinder will retract at.
RS-232 cable	The cable that connects the Pump controller to the computer and carries the serial data communications.
run conditions	The various text messages that are displayed in the motion status field when the pump cylinder is operating.
rupture	A breaking or opening.
safety pressure	This is the pressure which, if exceeded, the pump cylinders will stop pumping. Quizix pumps have three built-in safety pressure systems: digital safety pressure, the analog safety pressure and the safety rupture disk pressure.
safety rupture disk	A metal disk that is installed in a safety rupture disk assembly.
safety rupture disk assembly	This includes the safety burst disk holder, the safety rupture disk, compression ring, locking fitting and relief fluid exit. One is installed on each pump cylinder to burst in the case of overpressure, caused by a malfunction.
safety rupture disk exhaust port	Located on the safety burst disk assembly, this port should be connected by the user to a dump location in case of ruptured disk activation and fluid release.

schematic	A drawing of electrical or fluid connections.
scroll	The main window of the PumpWorks software has a left and right arrow in a bar along the bottom of the window. This allows you to move, or scroll, left or right to view all of the pump cylinders.
seal assembly	This includes the seal, seal back-up ring, and the seal retaining nut.
seal retaining nut	This is a threaded nut, used to keep the seal, and seal back-up ring inside of the cylinder barrel.
seal support ring	This is a cylindrical ring which sits inside the cylinder barrel and is used to support high temperature seals.
sensor board	This board keeps track of where the piston is and sends that information to the pump controller. The sensor board is located at the rear of the pump cylinder behind the ball screw.
sensor cable	This connects the pump cylinder sensor board to the interface box.
sequencer	A programming language available in the PumpWorks software to set up and automatically control complex pump operations.
serial port or serial communications port	The serial data cable from your controller plugs into this slot on the back of your computer. It is also called the Com Port or the Communications Port.
servo	A servo operates to keep a selected parameter constant by changing one or more other parameters.
servo extend	The piston is in the process of extending in order to achieve the desired pressure.
servo retract	The Piston is in the process of retracting in order to achieve the desired pressure.
set direction	This is used in independent operating mode to instruct a specific pump cylinder to either extract or retract.
set pressure	The field where the user sets the pressure that the pump will pump at when operating in constant pressure or constant delta pressure mode.

set flow rate	The user sets the rate the pump flows at when operating in a Constant Rate mode.
side covers	The plastic or aluminum part that covers the side rails of the pump cylinders
side rails	These are located under the left and right side covers of the pump cylinders and keep the ball nut from spinning freely when under load, or pressure.
slope	at an angle
soft limit switch	This switch is located on the sensor board. When activated, this switch quickly stops the piston from moving any further in the direction it had been moving. However, the piston is able to move in the opposite direction.
software	A computer program which, in this case, operates the pump system.
software version	This is a number which indicates which version, or code number, of the PumpWorks software you are using. It is viewed from the menu item titled “software versions”. It also tells you the code number of the software in the controller.
software zero offset range	Range of values that the user may input to change the zero point setting on a pressure transducer.
solvent	This is a petroleum based product used for cleaning.
speedbite fittings	See Autoclave speedbite fitting
speedbite plug protectors	A plastic insert used to protect speedbite fittings, or ports, during shipping.
speedbite plugs	A solid metal piece that completely seals a fluid port.
speedbite tubing port	A fluid port designed to fit an Autoclave Speedbite Fitting.
SS	This is an abbreviation for stainless steel.
stainless steel	This is a type of steel which is mostly resistant to corrosion.
standby pump cylinder	When two pump cylinders are being operated in a continuous flow delivery mode, the cylinder that is filling with fluid and pre-pressurizing is the standby pump cylinder. The deliver valve of the standby pump cylinder is always closed.
standby time	The time it takes for the standby pump cylinder to fill and pre-pressurize.

status bar	This is the horizontal bar that is on the bottom of the main window in PumpWorks software and provides messages regarding the status, or condition of the controller(s), data logging, sequencer and error messages.
steady state	constant or unchanging
stepper motor	The motor attached to the pump cylinder which rotates in the direction and at the speed dictated by the controller.
stopped conditions	Text messages in the motion status to tell you if the piston is in Max Extend or Max Retract, or if it is stopped in between these two points.
stroke volume	The amount of fluid the pump cylinder is capable of pumping during one piston stroke.
symmetrical	Something that is the same on both sides.
system level integration	The user's entire experiment is controlled by the Quizix PumpWorks software.
T-type seals	A type of seal that is shaped like a sideways "T" and is usually made of an elastomer.
tab key	Press the Tab key on your computer keyboard to move from one box to the next.
teflon	A unique polymer with excellent anti-friction and anti-corrosion properties.
tiled	The computer positions the open files so all that are open, two or more, are entirely in view at the same time.
tilt angle	The 0 to 15 degree angle, that the pump cylinders are positioned at.
time formats	There are three options for recording time, the actual time and date as set on your computer, elapsed time or cumulative time.
titles	PumpWorks software allows you to provide your own column headings, or titles, for you Data Log.
torque	A turning or twisting force.
torque wrench	A wrench that has a gauge built into it which allows the user to tighten nuts and bolts to a specified degree of force, or torque.

transducer assembly	The transducer assembly includes the transducer, transducer cable and fluid tubing.
transducer cable	This cable connects the pump controller to the pressure transducers.
transducer calibration	See calibrate
trapped gas	Gas that cannot be easily expelled or removed from the pump system.
trigger switch	This switch on the sensor board is sensed by the PumpWorks software to automatically tell the controller that the Piston has reached the end of its stroke.
tubing	!/8” and 1/4” tubing is used to connect the pump cylinders, valves and Pressure Transducers in the pump system.
unacknowledged	Not yet corrected.
unidirectional	Moving or operating in one direction only.
uninterruptible power supply (UPS)	A source of power that will continue if the main power source stops or has a surge of power.
unresolved	Still exists, not yet solved or corrected.
vacuum grease	A type of grease used to lubricate the CV valves.
valve	An air-actuated valve manufactured by Vindum Engineering that controls the flow of fluid.
valve assembly	A collection of CV valves, tubing, air lines and pilot solenoids.
valve cable	This cable connects the pump controller to the pilot solenoids.
valve cable extension	This is an extension that can be added to the valve cable to allow the pilot solenoids to be located a longer distance from the controller.
voltage setting	The power your system is set to run on, either 110 to 120, or 215 to 240 volts. This must match the electric supply for your country.
volume	A measured quantity or capacity, usually measured in milliliters or liters.
voltage setting	This is the voltage range the equipment is set to operate on. This must match the electric supply that your country operates on, either 110 to 120 or 215 to 240 volts.

INDEX